NORTH CAROLINA

DEPARTMENT OF CONSERVATION AND DEVELOPMENT

R. BRUCE ETHERIDGE, DIRECTOR

DIVISION OF MINERAL RESOURCES

JASPER L. STUCKEY, STATE GEOLOGIST

BULLETIN NO. 42

Chromite Deposits of North Carolina

BY

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AND

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PREPARED AND PUBLISHED IN COOPERATION WITH THE TENNESSEE VALLEY AUTHORITY

UNDER THE DIRECTION OF

JASPER L. STUCKEY, NORTH CAROLINA DEPARTMENT OF CONSERVATION AND DEVELOPMENT

AND

H. S. RANKIN, TENNESSEE VALLEY AUTHORITY

RALEIGH

1942

North Carolina
Department of Conservation and Development
R. Bruce Etheridge, *Director*

Division of Mineral Resources
Jasper L. Stuckey, *State Geologist*

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Geology and Mining
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Geophysics
Gerald R. MacCarthy

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MEMBERS OF THE BOARD OF CONSERVATION AND DEVELOPMENT

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Raleigh, North Carolina
October 7, 1942

To His Excellency, HON. J. MELVILLE BROUGHTON,
Governor of North Carolina.

SIR:

I have the honor to submit herewith, as Bulletin No. 42, a report on chromite deposits of North Carolina.

Chromite is classed as a strategic metal and is needed in larger quantities for war use. This report, it is hoped, will point out opportunities for the production of chromite in North Carolina which will lead to its production on a scale which will be a contribution to this country's war efforts.

Respectfully submitted,

R. BRUCE ETHERIDGE,
Director.

PREFACE

Chromite has been known to occur in North Carolina for many years and has been referred to briefly in the literature from time to time, but the present report entitled "Chromite Deposits of North Carolina" is the first attempt to bring together in one publication detailed information on chromite deposits of the State.

The investigation has been conducted in cooperation with the Tennessee Valley Authority in an effort to furnish information that may lead to an increased production of chromite in the present emergency. In addition to geological examinations, some of the more promising areas were investigated by geophysical methods. While no large bodies of ore were discovered, it is hoped the information contained in the report may be of value to those interested in the chromite deposits of North Carolina.

JASPER L. STUCKEY,
State Geologist.

CHROMITE DEPOSITS OF NORTH CAROLINA

SUMMARY

Since 1870 chromite has been known to occur in western North Carolina in, and closely associated with, the dunite (olivine) deposits of the area. All the chromite deposits are small, usually only a few hundred tons in each deposit. Most of the chromite is rather low grade, that is, the chromium oxide content is less than 45 per cent and the chromium-iron ratio is less than 2.5 to 1. However, there are a few occurrences where the chromite when concentrated is high grade with a Cr_2O_3 content greater than 48 per cent. The two principal occurrences of high grade ore suitable for beneficiation are the Day Book, (Yancey County), mainly a vein deposit, and the Democrat, (Buncombe County), mainly a placer-residual deposit.

For over 50 years there has been sporadic production, mainly during war times, of chromite from the North Carolina deposits, the total probably being less than 1000 tons. The future production will also be intermittent with the main production during abnormal times. These North Carolina deposits are best suited to remain as reserves for limited production during times of national emergency.

Careful geological investigation of all the known occurrences of chromite in the area indicated that the formations at Webster and Democrat offered the best chances for containing concealed ore bodies of commercial size and small selected areas were surveyed by magnetic geophysical methods. Although these surveys did not show any outstanding magnetic features that indicated the existence of large chromite bodies, they did find several small magnetic "lows" which indicated the probable existence of some small lenses. To prove more definitely the presence or absence of chromite under the magnetic "lows", three of these "lows" were tested by six core drill holes.

The core drilling results were not very encouraging as no chromite bodies were encountered of sufficient size to be commercially developed under normal conditions. However, all six holes intersected some chromite, mainly disseminated material of about 3 per cent chromite. Apparently the magnetic "lows" were caused by the presence of underlying lean disseminated chromite. One of the drill holes at a depth of 97 feet intersected a two-foot zone of vein chromite which apparently is the continuation of the same vein showing on the surface almost directly over the point of intersection.

The magnetic survey and core drilling proved that there is insufficient difference in magnetic properties between the chromite and enclosing dunite mass to outline accurately the ore body by standard magnetic geophysical methods. In addition, the core drilling showed that the North Carolina chromite ore bodies are small disconnected lenses with much lean or barren area between.

If the shortage of chromite should become sufficiently acute to justify the high cost of chromite production from the North Carolina deposits, the following occurrences merit consideration:

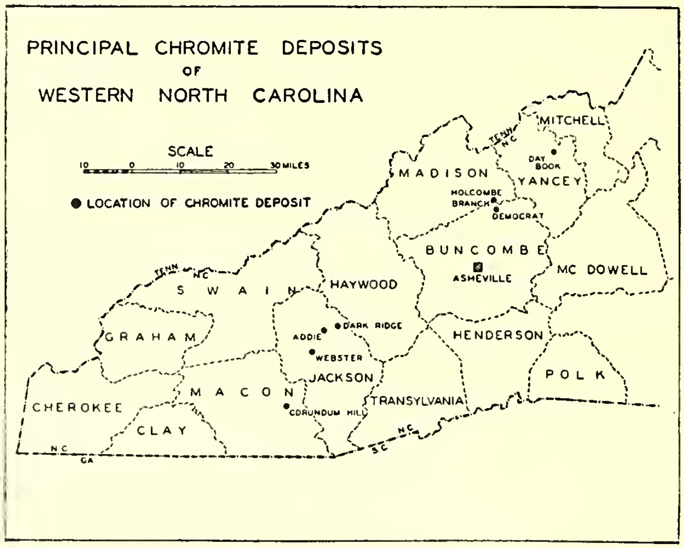
1. The residual-placer chromite at Democrat, Webster, and Corundum Hill.

2. Vein and lens chromite at Day Book and Dark Ridge.

3. Disseminated and lens chromite at Webster.

It is estimated that each of these prospects can furnish several hundred tons of chemical grade (plus 45 per cent Cr_2O_3) chromite per year, and there are several other smaller occurrences from which a few tons could be recovered.[1]

PLATE I



INTRODUCTION

The principal occurrences of chromite in western North Carolina are limited to a few localities in Buncombe, Jackson, Macon, Madison, and Yancey Counties. The most important deposits in these counties are the Day Book, Yancey County; Democrat, Buncombe County; and Dark Ridge and Webster, Jackson County. During abnormal economic conditions or when chromite value was over $50 per ton, small tonnages of chromite were produced from these and other smaller deposits, usually less than 200 tons from each during the period. All of these deposits are accessible by good all-weather roads and the Webster and Dark Ridge occurrences are on or near the railroad.

The purpose of this survey was to locate the North Carolina chromite deposits, appraise their economic aspect, and make available information regarding these deposits so that the best of them could be put into immediate production if war conditions become such that production from these deposits is essential to the national security. Magnetic geophysics had not been used in locating chromite ore bodies in the Southern Appa-

1. Eckel, E. C., and Hunter, C. E., "Iron, Chromite, and Nickel Resources of the Tennessee Valley Region," TVA Geologic Bulletin No. 10, (1938) p. 20.

lachians; therefore, this method of prospecting was included to determine its value in this area. The magnetic survey was followed by core drilling to check the magnetic results and to determine the practicability of blocking out North Carolina chromite ore by core drilling.

The field work was done as a cooperative project between the Division of Mineral Resources of the North Carolina Department of Conservation and Development and the Regional Products Research Division of the Commerce Department, Tennessee Valley Authority, and extended from June 17, 1941, to September 16, 1941. The survey was under the general supervision of Dr. Jasper L. Stuckey, State Geologist of North Carolina and Mr. H. S. Rankin, Senior Mining Engineer, Tennessee Valley Authority. Mr. Charles E. Hunter, Associate Geologist, Tennessee Valley Authority, and Mr. T. G. Murdock, Assistant State Geologist, North Carolina, were in charge of the field operation. Dr. Gerald R. MacCarthy, Professor of Geophysics and Geology, University of North Carolina, conducted the magnetic geophysical survey. Five student aides, Mason K. Banks, John W. Harrington, R. S. Ingle, Roy L. Ingram, and William T. McDaniel, Jr., were employed in conducting the survey.

The authors acknowledge with appreciation the kindly assistance of many local residents of western North Carolina, and especially that of Mr. Julius H. Gillis, of Olivine Products Cpn., Webster, and Mr. Marshall Gravatt, of Southern Mineral Cpn., Democrat.

ECONOMICS AND USES OF CHROMITE

The War Department as early as 1917 placed chromite high on the list of strategic minerals because of its limited domestic occurrence and its essential use in the production of armaments. It is necessary to depend almost entirely on imports. Chromite ($FeCr_2O_4$) is the only commercial mineral used as an ore of chromium and is converted in an electric furnace to ferro-chromium before it is added to the steel bath to make alloys and stainless steel. Chromium plating is used in the cutting tool industry to produce a hard durable surface, and chromite brick and ground chromite are used as neutral refractories in furnace construction. Chemical industries use chromium salts in electroplating, dyeing, tanning, pickling nonferrous metals, and making pigments.

In the United States 50 per cent of the consumption of chromite is for metallurgical purposes, 40 per cent for refractory purposes, and 10 per cent for chemical and other purposes.[1]

Between the years 1925 and 1940 the average domestic price was about $20 per ton. Since the latter date the market price has continued to increase, and during the first quarter of 1942 it exceeded $40 per long ton of 48 per cent Cr_2O_3 (with a Cr:Fe ratio of 2.5:1) f.o.b. mines. During 1917-1918 the price went above $70.00 per ton.

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1. Seil, G. E., Chromite (Chapter): Am. Inst. Min. and Met. Eng., Ind. Mineral and Rocks, New York, 1937, p. 199.

GEOLOGY

General Geology

The occurrence of chromite in North Carolina is restricted almost entirely to the mountainous western part of the State. Chromite in quantities greater than a trace is found associated only with peridotite rocks, mainly of the olivine variety, which are intrusives into crystalline gneisses and schists of Pre-Cambrian age. These metamorphics have also been intruded by younger granites and pegmatites ranging in age from Pre-Cambrian to Carboniferous. In these Pre-Cambrian formations the prevailing foliation is northeast-southwest and commonly dips toward the southeast, but there are considerable local variations in both strike and dip, and in some places the rocks are contorted in a complicated manner.

The olivine formations are usually less than a mile in length, although some extend for several miles, and the width is generally about one-fourth to one-third of the length. These olivine chromite-bearing formations usually occur with hornblende gneiss,[1] but may also occur with the micaceous gneiss and schist.[2] The chromite occurs in the olivine formations as disseminated crystals in an olivine matrix, disconnected small lenses, narrow veins, or as relatively large crystals in talc veins. In addition to this primary chromite, there are residual and placer deposits that have been weathered free from the olivine formation. It is only with the residual and placer deposits that tonnage estimates of reserves can be made. The primary chromite in the dunite is so irregular in occurrence and extent that estimates cannot be made and only the ore in sight can be considered as reserve.

The geology of these olivine formations is described in more detail in the publications "Corundum and the Peridotites of Western North Carolina[3] and Forsterite Olivine Deposits of North Carolina and Georgia", both by the North Carolina Geological Survey[4].

Mineralogy of Chromite

Chromite is iron-black to brownish-black in color; with hardness of 5.5; specific gravity, 4 to 4.6; luster submetallic to metallic and sometimes feebly magnetic. It varies greatly in composition as it is an isomorphic mixture. The chromium atom is replaceable by several other isomorphic elements. This relationship has been described by J. Volney Lewis,[5] as follows:

> Variations in color, luster, and degree of translucence are comprehensible in view of the chemical character of chromite. Its composition is commonly represented by the formula $FeCr_2O_4$, or FeO, Cr_2O_3, which corresponds to 67.86 per cent chromic oxide (Cr_2O_3). Few analyses, however, show even as much as 60 per cent Cr_2O_3, and they range from this down to 35 per cent and lower.
>
> This wide variation, which is obviously of the greatest practical importance, arises from the fact that chromite is a member of an isomorphous group of min-

1. Roan Gneiss. Arthur Keith, "Mount Mitchell Folio, North Carolina-Tennessee," Geological Atlas of U. S. No. 124, 1905).
2. Carolina Gneiss. Arthur Keith, *op. cit.*
3. Pratt, J. H., and Lewis, J. V., "Corundum and Peridotites of Western North Carolina," N. C. Geol. and Economic Survey, Vol. 1, 1905.
4. Hunter, C. E., "Forsterite Olivine Deposits of North Carolina and Georgia." N. C. Dept. Cons. and Devel. Bull. 41, 1941.
5. Lewis, J. V., "Chrome-Ore Deposits in North Carolina," Engineering and Mining Journal, Vol. 109, No. 20, M. 1920, pp. 1112-1114.

erals which are capable of mingling in all proportions to form homogeneous "mixed crystals". In other words, the crystals and grains of such a mineral may show its own characteristic constituents to be replaced in varying degree by the corresponding elements of other members of the group. The spinel group, as it is called, includes spinel, $MgAl_2O_4$; hercynite, $FeAl_2O_4$; magnetite, $FeFe_2O_4$; (mitchellite); and a number of other related aluminates. Hence chromite, when it is crystallizing, may have a part of its ferrous iron replaced by magnesium, which is an abundant constituent of the peridotites; and in a similar manner aluminum and ferric iron, when present, may be substituted for a part of the chromium. The latter process reduces the chromium content, and therefore yields a mineral of less value; the former makes a desirable reduction in the percentage of iron. The result is equivalent to mixing the molecules of the four minerals named above, and hence the composition of chromite in general may be represented by the formula $(Fe, Mg)\ (Cr, Al, Fe)_2O_4$.

It follows that the limit to the possibility of improving the grade of a chrome ore by concentration is always lower, and may be far lower than that set by the theoretical chromite molecule, $FeCr_2O_4$. For any particular locality or deposit that limit can be determined only by chemical analyses of sufficient number and accuracy to establish the average composition of the essential ore-mineral, chromite.

In addition to the variations in the composition, some of the primary chromite has been partly altered to chlorite. The chromite is rather difficult to free from the gangue minerals, olivine, serpentine, talc, chlorite, and various secondary minerals. At Webster, kammererite, a peach-blossom colored chromium-bearing chlorite, is found associated with almost all of the chromite.

DESCRIPTION OF CHROMITE DEPOSITS

For convenience of description of deposits, the occurrences are taken up by counties. The deposits have been named after prominent geographic points at, or near, the deposit and in most cases these names coincide with the names applied to these deposits in previous reports. No attempt has been made to make chromite tonnage-reserve estimates because of the irregular nature of these deposits, which is discussed elsewhere in this report.

BUNCOMBE COUNTY

DEMOCRAT AND MORGAN HILL CHROMITE PROSPECTS

Chromite occurs with a dunite formation about 3000 feet west of Democrat, Buncombe County, the main part occurring between Ivy Park Church and Ivy River (see Plate 2). The chromite occurs as placer-residual deposits, small massive veins and lenses, and disseminated crystals in dunite.

PLACER-RESIDUAL CHROMITE

Placer chromite mixed with clays and gravels occurs along a small drain on the west contact of the formation. This placer area is about 1200 feet long and averages 100 feet wide. It is not very thick, averaging less than eight feet to bedrock.

This placer area was partly worked during 1917-1918 at which time the chromite was recovered by washing and tabling. It is reported that the chromite recovered contained at least 48 per cent Cr_2O_3. The chromite occurring in this placer consists almost entirely of small (1/8 inch or less) octahedral crystals making up about four per cent of the placer.

On the northeastern slope of the dunite formation towards Ivy River and Democrat there is residual and placer chromite. This area consists of about three acres and is underlain by clay, gravel, and placer material averaging approximately five feet in thickness. During the summer of 1941 part of this placer area was worked for chromite. The material was recovered by a hydraulic process described elsewhere in this report. The placer is reported to contain five or six per cent chromite, most of which is apparently recoverable. The chromite liberated from the weathering of dunite consists mainly of octahedral crystals and small fragments of massive chromite. The following is a chemical analysis[1] of the chromite recovered by the portable plant:

Cr_2O_3	Fe_2O_3	Si	P	S	$Cr:Fe$
55.52	28.50	0.80	0.07	Trace	1.9:1

There is an area underlain by residual chromite near the southwestern end of the Democrat dunite formation. This material is principally on the southeast side of the highway N. C. No. 695 about 1500 feet southeast of Morgan Hill Church. There are about six acres underlain by the residual-placer chromite, principally in clay, averaging about five feet deep. This placer was drilled and sampled a short time ago and it is reported to contain about three and one-half per cent Cr_2O_3.

MASSIVE AND DISSEMINATED CHROMITE

In the Democrat dunite formation there are several small lenses of massive and vein chromite. Small pits have been made on showings of massive and vein material at a point a few hundred feet southwest of the McKinney family cemetery. This location is also a few hundred feet south of a feldspar mine on the south side of Ivy River west of Democrat. One of these pits is 6 by 12 feet and 6 feet deep. Disseminated chromite shows in the walls of the pits, and parallels the major joint system of the dunite which is N 25° E. It is reported that about five tons of massive chromite was removed from this pit, of which one ton remains beside the pit and contains about 80 per cent chromite. The fractures are filled with talc, kammererite, and nickel silicate minerals which were formed in fracture planes some time after the chromite.

A small pit occurs about 50 feet northeast of the one just described. This pit appears to have encountered about one-half ton of vein chromite. Material on the dump indicates that the vein was about six inches wide.

A zone of rather rich disseminated chromite occurs a few hundred feet northeast of the feldspar mine. This location is 300 feet northwest of Ivy River. During 1917-1918 a shaft was made in this disseminated ore to a depth of about 50 feet and is reported to have cut through a zone of rich disseminated chromite ore about three and one-half feet

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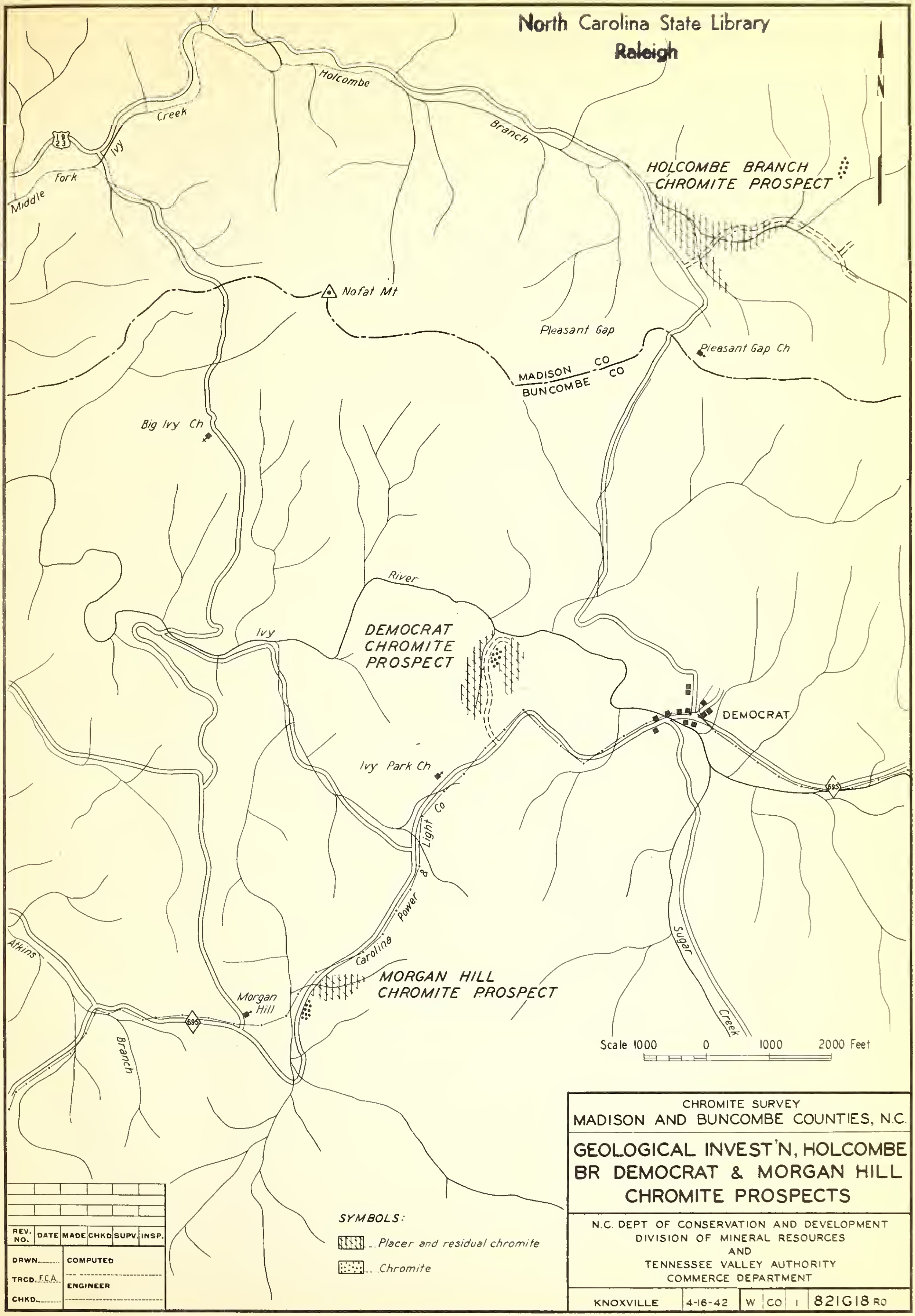
1. Analysis by J. W. H. Aldred, Research and Development Division, Tennessee Valley Authority, Wilson Dam, Alabama.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Ivy Creek
Middle Fork
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HOLCOMBE BRANCH CHROMITE PROSPECT
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MADISON CO
BUNCOMBE CO
Big Ivy Ch
Ivy River
DEMOCRAT CHROMITE PROSPECT
DEMOCRAT
Ivy Park Ch
Carolina Power & Light Co
695
Sugar Creek
Atkins Branch
Morgan Hill
MORGAN HILL CHROMITE PROSPECT
Scale 1000 0 1000 2000 Feet
SYMBOLS:
Placer and residual chromite
Chromite
CHROMITE SURVEY
MADISON AND BUNCOMBE COUNTIES, N.C.
GEOLOGICAL INVEST'N, HOLCOMBE BR DEMOCRAT & MORGAN HILL CHROMITE PROSPECTS
N.C. DEPT OF CONSERVATION AND DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
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wide. The disseminated zone strikes northeast and southwest and dips to the southeast. The disseminated ore consists of thickly spaced crystals in an olivine matrix with the chromite making up as much as 75 per cent of the material. An analysis of the chromite, including the olivine matrix, contains 29.5 per cent Cr_2O_3.[1]

About 100 feet to the southeast of this shallow shaft there is an exposure of similar disseminated chromite which shows at several points, varying from a few inches to three feet in width. The extent of this disseminated ore is not known.

All of these disseminated zones of ore are probably along a fracture system in the dunite. The richer part of the ore is thought to occur as irregular lenses.

VEIN AND DISSEMINATED CHROMITE

Vein and disseminated chromite occurs in the dunite at a point about 1100 feet northeast of Morgan Hill Church and a few feet east of the highway, N. C. No. 197 (see Plate 2). A cut has been made along the exposure which is about 25 feet east of the west contact of the dunite formation; it is 50 feet long, 12 feet wide, and averages 15 feet deep. All the olivine exposed in the cut is fine-grained and a light yellowish green in color. Most of this olivine contains disseminated chromite which is fine-grained but crystals range in size up to ¼ inch in diameter.

In the southern part of the pit the disseminated chromite zone is about 4 feet wide and probably contains about 60 per cent chromite. In the extreme southern end of the pit, the chromite zone has narrowed to a width of about 18 inches. In the northern end of the cut only a small amount of chromite is exposed. However, the cut appears to have been driven too far to the west and, therefore, away from the disseminated chromite zone.

At the center of the cut is a shaft 10 by 10 feet which has been sunk to a depth of about 75 feet. This shaft is timbered and full of water. The material on the dump indicates that the shaft encountered rich disseminated and vein chromite of a rather black color but shows minor alterations to kammererite in places. It is not known how much chromite was removed from this shaft but probably less than 10 tons.

LEICESTER CHROMITE PROSPECT

State Highway No. 63 crosses a dunite formation one-fourth mile east of Leicester, Buncombe County. This dunite is highly serpentinized and weathered, and contains a small amount of disseminated chromite in the form of octahedral crystals. Where the dunite has weathered, these crystals have accumulated in the residual material in a sufficient amount to be considered a possible source of chromite. The dunite underlies about six acres.

MADISON COUNTY

HOLCOMBE BRANCH CHROMITE PROSPECTS

Chromite occurs on Holcombe Branch 1200 feet north of Pleasant Gap and one and one-fourth miles southeast of Beech Glen, Madison County, and is associated with the Holcombe Branch dunite formation (see Plate 2). Parts of the dunite rock contain about

1. Analysis by Tennessee Valley Authority Minerals Testing Laboratory, Norris, Tennessee.

two per cent disseminated chromite crystals, which are usually associated with sound olivine. The disseminated chromite is most noticeable in the road cut along the north side of the branch.

There is placer chromite along Holcombe Branch across the dunite formation and downstream for several hundred feet below the contact of the formation. This placer material extends on each side of the branch for about 75 feet and appears to have an average thickness of about 4 feet. Pieces of chromite 4 inches in diameter are rather numerous in the placer material but the remainder is mainly coarse rock. The chromite-bearing zone extends along the creek for a distance of about 1,000 feet.

Vein chromite associated with corundum occurs in the northeast part of the Holcombe Branch dunite. This occurrence, a short distance west of the east contact, is north of the branch and about 3,000 feet northeast of Pleasant Gap. The chromite was encountered in mining corundum a number of years ago. The corundum shafts are now caved, so the actual chromite-corundum veins could not be examined, but the dumps around the shafts contain blocks of chromite-corundum, many of which are two and one-half feet or so in diameter. The chromite is very black; the corundum is massive and slightly pink. This prospect is worth investigation because of the possibilities of producing chromite and corundum from the same operation.

YANCEY COUNTY

DAY BOOK CHROMITE PROSPECT

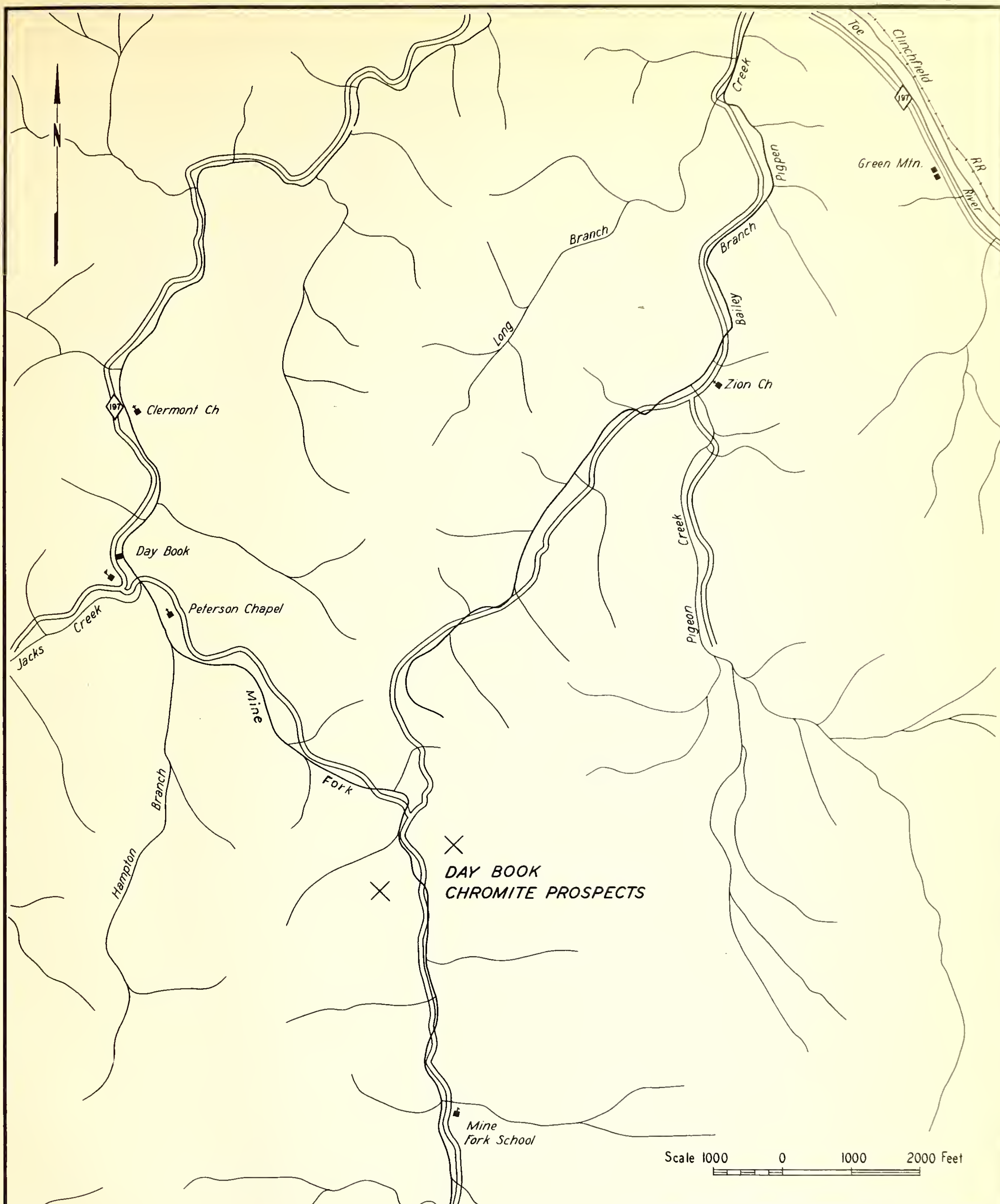
The Day Book chromite prospect (old Ray Mine) occurs one mile southeast of Day Book, Yancey County, (see Plate 3). The chromite is associated with a lens-shaped dunite formation trending northeast-southwest and occurring on both sides of Mine Fork Creek.

Near the crest of the hill on the east side of Mine Fork Creek, there is an abandoned shaft in one of the chromite prospects about 50 feet from the northeast contact. This deposit was first prospected about 1901 by shallow trenches and pits. During 1917-1918 it was again opened up by a shaft 75 feet deep with some drifting near the bottom. At this time two carloads of ore were produced. The shaft encountered a vein of chromite which was reported to be about 15 inches thick, and numerous tiny veinlets associated with the wall rock. It appears that the mining operations as practiced were quite wasteful as only the large chunks were shipped and the smaller veinlets were thrown away instead of being milled. The chromite found in the old dump is an unusually coarse-grained material and occurs directly in contact with extra high-grade, coarse-grained olivine. In addition to the chromite and olivine, there is much soapstone and talc on the dump. The chromite in the dump is tar black in color on a fresh surface and coarsely crystalline, the crystals being distorted and elongated by squeezing and fracturing.

A chipped sample of the chromite including some matrix from the dump has the following analysis:[1]

Cr_2O_3	Fe_2O_3	SiO_2	Al_2O_3	MgO	*Total*	*Cr:Fe*
44.20	20.05	0.30	21.30	14.48	100.33	2.14:1

1. Chemical analysis by W. A. Reid, Division of Mineral Resources, North Carolina Department of Conservation and Development, Raleigh, N. C.



CHROMITE SURVEY, YANCEY CO., N.C.

GEOLOGICAL INVESTIGATION
OF
DAY BOOK CHROMITE PROSPECT

N.C. DEPT OF CONSERVATION AND DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

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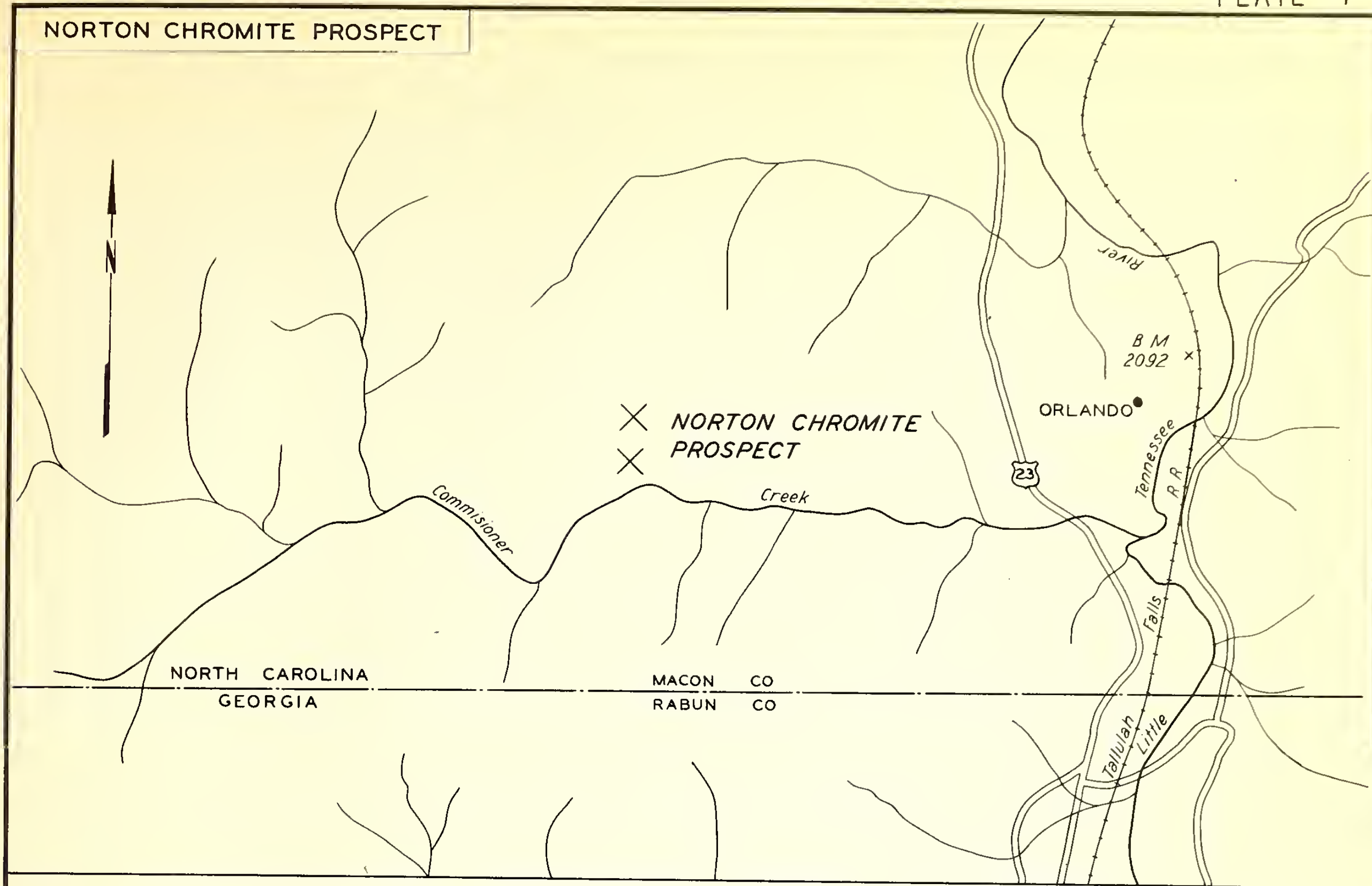

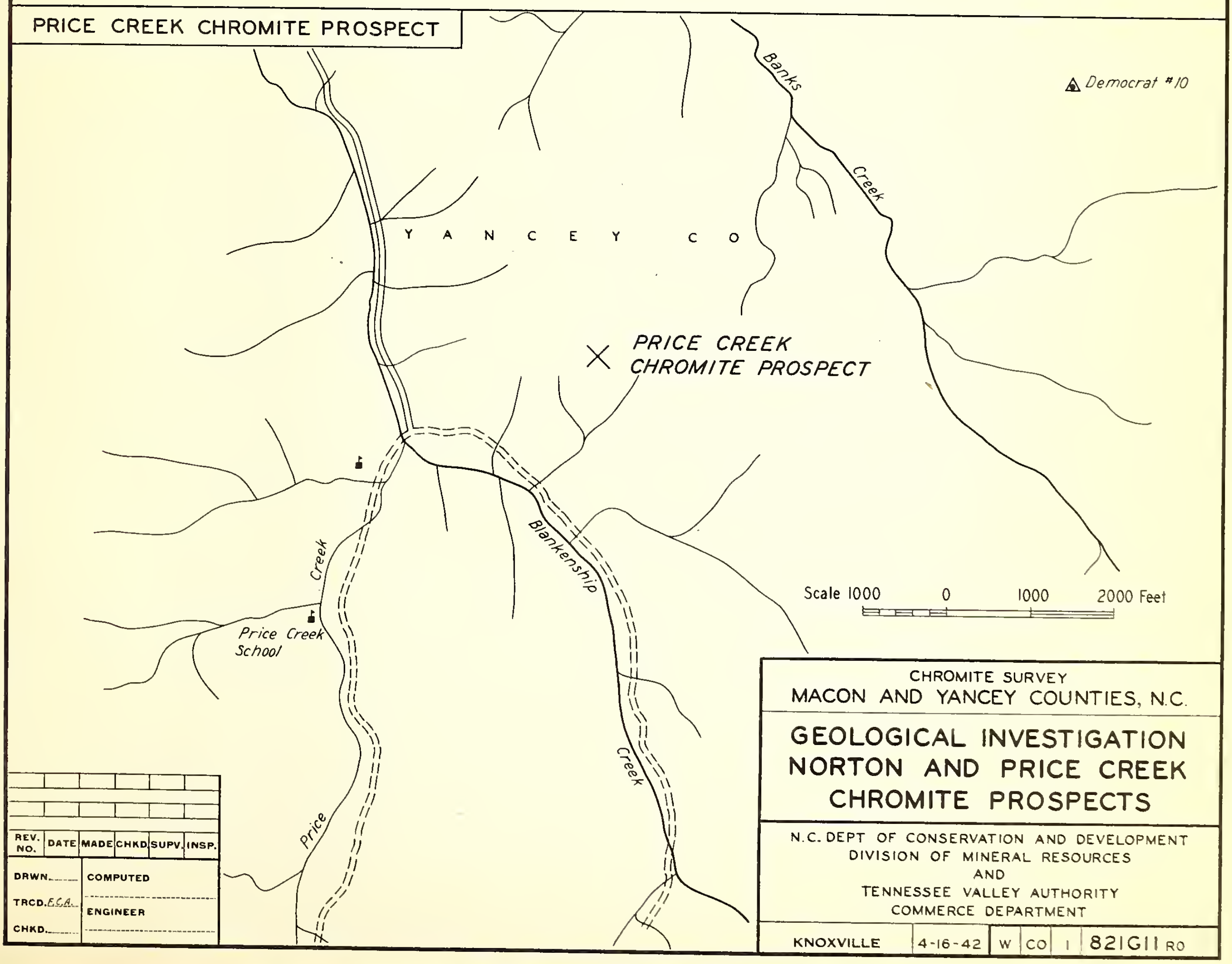

CHROMITE SURVEY
MACON AND YANCEY COUNTIES, N.C.

GEOLOGICAL INVESTIGATION
NORTON AND PRICE CREEK
CHROMITE PROSPECTS

N.C. DEPT OF CONSERVATION AND DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
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During 1917-1918 some prospecting by pits was carried out on the southwest end of the formation where some chromite was found similar to that on the other end. However, the prospecting probably uncovered less than ten tons of chromite, most of which is very black. It occurs as small pockets, most of which are vein-like segregations in fresh granular olivine. More prospecting at this point should reveal similar pockets of chromite. There are possibilities that a small tonnage of chromite could be recovered from the soil along the northern part of the dunite formation. The Day Book prospect is worthy of further development work.

PRICE CREEK CHROMITE PROSPECT

The Price Creek chromite prospect is located in Yancey County about one mile northeast of Price Creek school (see Plate 4). This occurrence is up the second branch on the north side of Blankenship Creek. The prospect consists of several pits on the east side of a hill about 100 feet above the creek. A small amount of chromite was mined here about 50 years ago. Around these pits and on their dumps there is relatively sound granular olivine. Chromite occurs in the dump material as small veins and large one-half inch blebs.

Pratt and Lewis[1] mention this prospect and state that a pocket of chromite yielded seven tons of ore and was then exhausted. An assay by Baskerville[2] gave a content, for a selected sample, of 59.20 per cent Cr_2O_3 and 25.02 per cent FeO.

The dunite formation at Price Creek is largely concealed by overburden. There may be other small pockets of high grade chromite concealed by this overburden.

JACKSON COUNTY

WEBSTER CHROMITE PROSPECTS

The town of Webster, Jackson County, is located on the western part of the Webster-Addie dunite ring dike.[3] There are a number of chromite prospects within a distance of one and one-half miles of Webster, most of which have been intermittent producers of chromite for short periods of time during the last fifty years. This small production has coincided with times when chromite was selling for abnormally high prices, such as the war period of 1917-1918. The tonnage and grade of the ore produced is not known, but the total is believed to have been less than 600 tons of merchantable ore.

The occurrence of chromite at Webster (see Plate 5) is of three types: (1) small lenses or pockets of massive or semi-massive chromite in fault zones or in the contact of the formation; (2) placer, or residual, material derived from weathered dunite; and (3) thickly spaced disseminated chromite crystals and small veins in relatively sound dunite. The chromite production at Webster has been from the massive lenses or the weathered disseminated material.

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1. Pratt, J. H., and Lewis, J. V., "Corundum and Peridotites of Western North Carolina," Vol. 1, N. C. Geological Survey, p. 382.
2. *Ibid.*
3. Hunter, C. E., "Forsterite Olivine Deposits of North Carolina and Georgia," N. C. Dept. Conservation and Devel. Bull. No. 41, (1941) p. 82.

Lenses of Massive Chromite

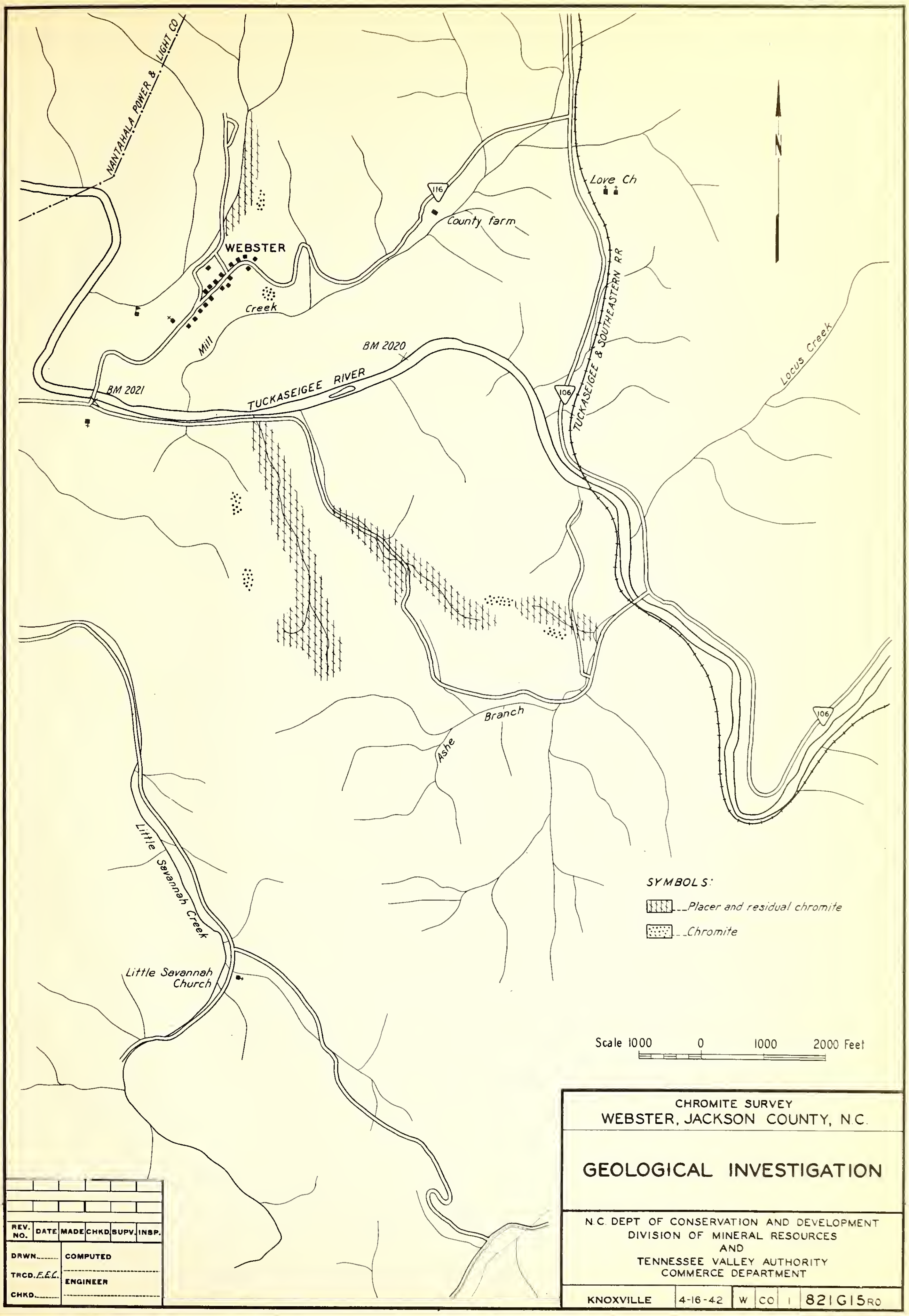
Float chromite of the massive very black type occurs in a field and along the small creek north of the town of Webster. The largest chromite float occurs along the east side of the creek at a point about 1,800 feet due north of the Webster Post Office and 1,000 feet south of the cemetery. In the field a few hundred feet east of the creek, pieces of massive chromite six inches in diameter are not uncommon. Some of these pieces appear to be clusters of crystals one-half inch or more in diameter which have had the crystal corners dissolved or replaced by chlorite. The source of this float chromite has not been determined but it is probably from a concealed pocket of chromite near the upper edge of the field. This area is worthy of prospecting.

A lens of massive chromite similar to the material described above has been partly mined out between the road and Mill Creek at a point about 800 feet southeast of the Webster Post Office. The old pits are partly filled because of the caving of the sides. This was one of the first deposits worked for chromite in the Webster area and the only one worked near the center of the dunite mass.

Other small lenses of semi-massive chromite occur along the western part of the dunite formation south of the Tuckasegee River. Most of these occurrences are in or near the western contact zone and less than one-half mile south of the river. The best of these exposures have been opened up by cuts or trenches and part of the past chromite production from Webster has come from these works. The pits and trenches are partly filled from caving and have a heavy growth of concealing vegetation. The ore exposed in the workings, and on the surface beside them, for the most part consists of clusters of rounded chromite crystals probably averaging one-fourth inch in diameter and separated by talc and chlorite. Even most of the massive chromite observed contains talc in the cracks. The ore as a whole has a dull black color and probably is of the high iron ratio variety. The size of these small chromite lenses is not known, but they are probably worthy of further prospecting.

A small lens of semi-massive chromite is exposed by a trench about one and one-half miles southeast of Webster. The pit is located west of the Tuckasegee River and about 1,200 feet due west of the mouth of Ash Branch. The pit is near the outside contact of the Webster-Addie dunite ring dike, and is a crescent-shaped cut about 100 feet long, 5 feet wide, and 15 feet deep. Most of the cut parallels the contact of the dunite formation but is located about 75 feet in from the contact. The cut encountered altered dunite and saxonite with fracture seams filled with nickel silicate minerals. The cut appears to have followed a fault along which there are small seams and lenses of chromite. The greatest amount of chromite was encountered at the extreme west end of the cut where the chromite is reported to have been about 3 feet thick at the thickest point exposed. It is reported that when the pit was abandoned, a chromite vein about 6 inches wide was showing in the bottom.

Probably about 20 tons of chromite was removed from this cut, most of which remains stocked beside the opening. This chromite consisted of blocky material mixed with talc and olivine with the size of these blocks ranging up to 1 x 1 x 2 feet. These angular blocks for the most part consist of small veins, clusters of rounded crystals, and thick disseminated chromite. The material appears to have been brecciated after it was formed,



CHROMITE SURVEY
WEBSTER, JACKSON COUNTY, N.C.

GEOLOGICAL INVESTIGATION

N.C. DEPT OF CONSERVATION AND DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

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with the fractures being filled with talc, chlorite, and small chromite crystals. The olivine associated with the vein chromite is sound green granular material suggesting a late intrusion. A chipped sample of chromite including the matrix from the material on the dump beside the pit has the following analysis:[1]

Cr_2O_3	Fe_2O_3	SiO_2	Al_2O_3	MgO	*Total*	*Cr:Fe*
22.61	18.91	16.90	16.70	24.62	99.74	1.16:1

It is logical to assume that similar chromite lenses are concealed along this fault zone. Continued prospecting in the immediate area might uncover more chromite.

PLACER AND RESIDUAL CHROMITE

In the Webster area there has been no attempt to recover placer chromite, although some chromite was washed out of the richest residual material during the last war. Some of the small creeks that have their entire drainage source on the dunite formation contain enough placer chromite to justify prospecting.

A small branch enters the Tuckasegee River about 500 feet northwest of the Olivine Products Corporation Plant southeast of Webster, and drains an area exclusively underlain by the dunite formation. Since it has a gentle drainage slope over 4,000 feet long, it is logical to assume that the chromite weathering out of the dunite rock would accumulate along this small drainage way. Samples taken from the bank of this branch and panned appear to contain up to 5 per cent chromite, most of which is in fragments less than one-eighth of an inch in diameter.

Another small branch enters the river about 300 feet northeast of the plant, and flows along the contact of the formation for part of its course. This branch is also about 4,000 feet long, but there is placer chromite only on the upper part of this branch over the dunite formation and down the branch for several hundred feet below the contact. Near the contact, or 2,500 feet from the plant, the placer material consists of small chromite fragments mixed with stream-transported gravels. At this point over an area of about two acres, pieces of chromite ranging in size from ½ to 10 inches in diameter are noticeable on the surface; the larger pieces consist of clusters of black shiny chromite crystals in a talc and chlorite matrix and the smaller pieces consist of crystals and small fragments of nearly pure chromite. In places part of the placer gravels and clays are probably at least 15 feet thick.

The upper left fork (northeast) contains placer and residual chromite along the branch and on the hill slopes on both sides, in some places more than 25 feet thick. The chromite in this area is mostly fine material less than ⅛ inch in diameter and is associated with clay containing chalcedony rock fragments.

At and near the gap, 2000 feet due west of the mouth of Ash Branch, there is an area of probably four or five acres, containing residual chromite. On both sides of this gap the dunite formation is weathered to a depth of at least 40 feet. In the gap a core drill hole encountered rock at a depth of 91 feet.

1. Chemical analysis by W. A. Reid, Chemist, Division of Mineral Resources, N. C. Dept. Conservation and Development, Raleigh, N. C.

DISSEMINATED CHROMITE

Near the gap 2000 feet due west of the mouth of Ash Branch, there is a zone of lenses of disseminated chromite ore. This ore zone occurs from 20 to 50 feet south of the inside contact of the Webster-Addie ring dike and is traceable from surface exposures and showings in cuts for an east-west distance of about 325 feet but is best exposed in the easternmost cut. At this point the ore is about 3½ feet wide and contains approximately 35 per cent chromite. Near the west end the disseminated zone is probably a little more than 3 feet wide and, in addition, contains a small amount of vein ore. The disseminated and vein chromite has a vertical dip and is associated with altered dunite in which the fracture zones are filled with nickel silicate minerals.

This area of disseminated chromite was worked during 1917-1918 and it is reported that four carloads of 45 per cent plus ore were recovered. Two open cuts, less than 100 feet long and about 25 feet wide, were made on the weathered part of the disseminated zone. The depth of the cuts probably did not exceed 25 feet (see Plate 9). It is reported that a shaft was sunk on the ore in the bottom of each cut to a depth of about 50 feet below the bottom of the cut. Ore was removed from each shaft as is indicated by sound dunite, containing disseminated chromite, scattered around the collar of the shafts. It is logical to assume that this type of ore would extend down for several hundred feet, probably as shoots plunging to the west. The mining activity at these cuts and shafts during 1918 has been described by Lewis.[1]

This area is the most promising one for the production of any substantial tonnage of chromite in the Webster area. The best of the weathered zone has been about worked out; so future production will have to be in the hard rock zone usually encountered about 50 feet below the surface.

ADDIE CHROMITE PROSPECT

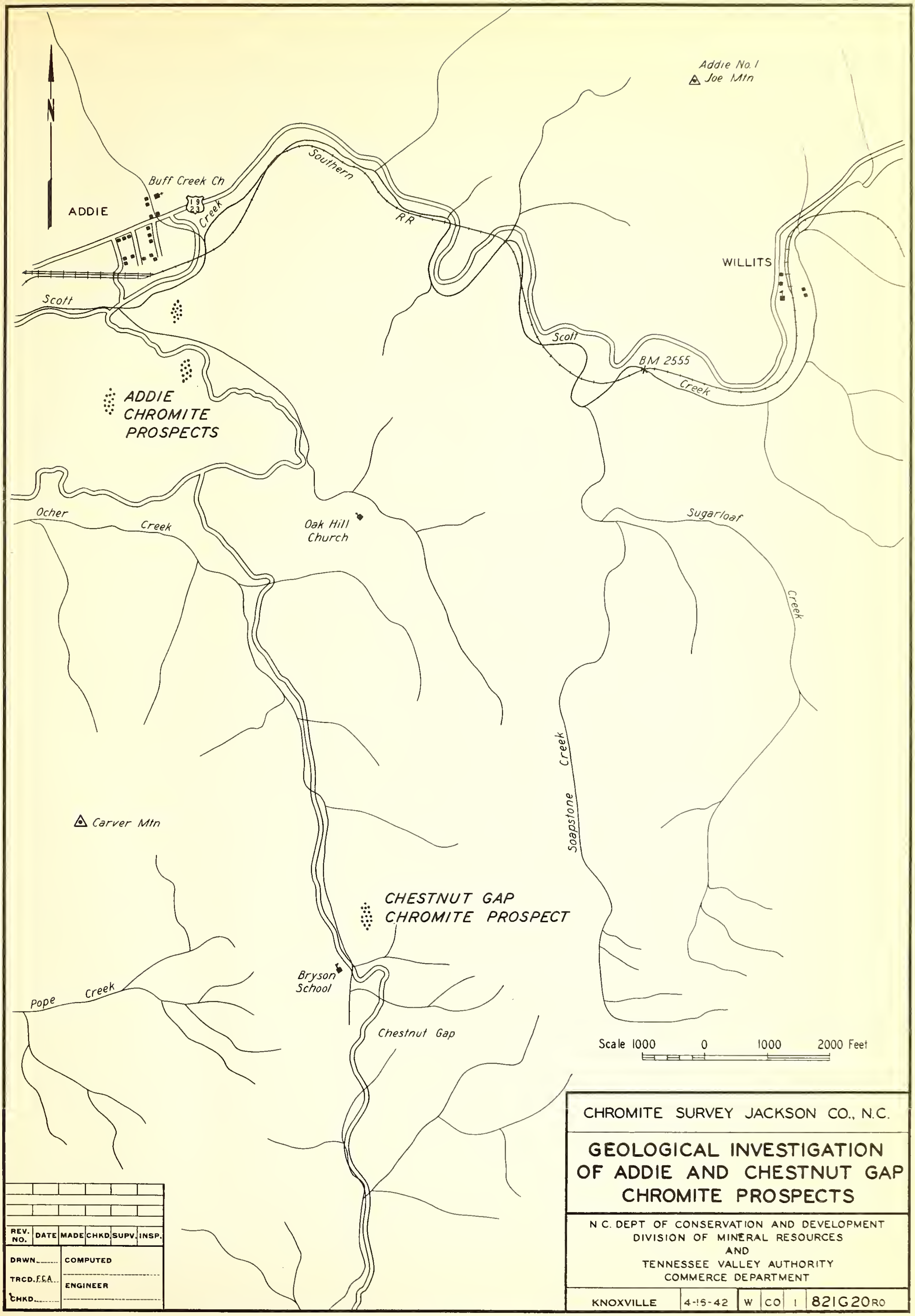
There are several showings of chromite in the dunite ring-dike in the vicinity of Addie, Jackson County, (see Plate 6). The chromite is best exposed in prospect pits located less than one-half mile southeast of the Southern Railway Station at Addie, and about the same distance east of the Fisher home.

One of these pits is on the north slope of a rounded hill 1,200 feet southeast of the station and the same distance east of the Scott Creek bridge. The pit is now partly filled, but it appears to have been about 6 feet deep with a diameter at the top of 5 feet. It is reported that about three-fourths of a ton of chromite was taken out. At the present time a one-half ton dump is beside the pit.

The chromite showing in the pit and that removed appear to have come from a small lens, probably originally about three feet thick, occurring in a fault zone. The chromite removed from the pit is composed almost entirely of fractured rounded blebs of black shiny chromite separated by talc, anthophyllite asbestos, and white chlorite. One-tenth of an inch is the average diameter of the individual blebs although some of them range up to one-half inch in diameter. These blebs seem to have been formed from massive chromite which has been crushed and shattered by faulting. The faulted and brecciated chromite was later cemented by the associated talc, chlorite, and asbestos.

1. Lewis, J. V., "Deposits of Chrome Ore in North Carolina." U. S. G. S. Bulletin 725, pp. 125-130.

PLATE 6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PROSPECTS
Ocher
Creek
Oak Hill
Church
Sugarloaf
Creek
Soapstone Creek
Carver Mtn
CHESTNUT GAP
CHROMITE PROSPECT
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School
Pope Creek
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CHROMITE SURVEY JACKSON CO., N.C.
GEOLOGICAL INVESTIGATION
OF ADDIE AND CHESTNUT GAP
CHROMITE PROSPECTS
N C. DEPT OF CONSERVATION AND DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
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The weak shattered zone in which the chromite occurs is a part of a 20-foot fractured area striking N 47° E and dipping 48° SE. There are several small showings of chromite within the shattered area, and associated with it is sound green granular olivine.

Chromite float can be found along the strike of the fractured zone both to the northeast and southwest of the pit for several hundred feet. The float is the same type material as that exposed at the pit. It it doubtful that there is enough chromite in this shattered zone to economically mine under normal conditions.

A chipped sample of chromite from the pit has the following analysis:[1]

Cr_2O_3	Fe_2O_3	SiO_2	Al_2O_3	MgO	*Total*	*Cr:Fe*
29.46	19.89	11.40	24.00	15.74	100.49	1.45:1

A small pocket of chromite was uncovered a few years ago in the outside curve of the road at a point 1,200 feet southeast of the station. The point at which the chromite was found is near where a small drain crosses the road. This location is southwest and along the strike of the fractured zone previously described, and therefore the occurrence is probably similar. It is reported that about 300 pounds of chromite was taken out of this location.

Float chromite is found on the crest of a narrow ridge at a point about 1,700 feet south of the station. This location also appears to be in the fractured zone cutting across the dunite formation in a northeast-southwest direction. The center of the float area is about 175 feet east of the west contact. The chromite has long been exposed to the weather but it has a similar appearance to that occurring at the pit on the round hill to the northeast, previously described.

Disseminated chromite in sound dunite occurs near the crest of a low ridge at a point about 2,000 feet southeast of Addie Station, with the best showing about 500 feet southeast and up the ridge from the olivine quarry of the Harbison Walker Company. The main part of the chromite occurs over an area about 50 feet wide with an additional small area occurring about 100 yards to the south along the crest of the ridge.

The chromite occurs as thickly spaced crystals which in the richer zones give the dunite a black banded appearance. The bands trend northeast and southwest with most of them dipping about 60° to the southeast. There are several small veins of massive chromite in the area which bring the content up to about 5 per cent. The richer disseminated veins may average about 1½ inches in diameter and contain 75 per cent chromite. The matrix material is sound granular olivine. Many of the chromite crystals around the edges are partly altered to chlorite. An analysis of an average sample of the disseminated material including the matrix shows that it contains 1.14 per cent Cr_2O_3.[2]

Under normal conditions it would not be economical to recover chromite from this disseminated material. If it ever should become desirable to produce this chromite, it should be attempted as a by-product from crushed olivine.

Placer and residual accumulations of crystals and fragments of chromite occur along the small streams and over part of the slopes on the dunite formation northeast of the

1. Chemical analysis by W. A. Reid, Chemist, Division of Mineral Resources, Department of Conservation and Development, Raleigh, N. C.
2. Analysis by Tennessee Valley Authority Minerals Testing Laboratory, Norris, Tennessee.

Fisher home. In some of the short and narrow drainage valleys on the formation, this placer material in the richer places probably contains 6 per cent chromite by volume. The total placer and residual reserve is thought to be less than 500 tons of recoverable chromite.

CHESTNUT GAP CHROMITE PROSPECT

A small unimportant chromite prospect occurs in the dunite ring dike one and three-fourths miles south of Addie and is exposed in erosion gulches on the Blanton farm a few hundred feet north of the farmhouse. This occurrence is on the headwaters of Ocher Creek due east of Carver Mountain and about 2,000 feet northeast of Bryson school (see Plate 6). The chromite occurs in a 3-foot shattered zone of dunite about 50 feet west of the east contact of the dunite formation. The zone strikes N 38° E and can be traced for a distance of about 50 feet. The chromite occurs as small lenses in this shattered area, mixed with massive soapstone, impure vein talc, anthophyllite asbestos, and vermiculite. The best exposed lens is 15 inches long and 8 inches wide. These small lenses consist of talc and small chromite crystals, making up a ground mass around larger chromite crystals. Some crystals were observed to be ½ inch or more in diameter. The chromite appears to have been crystallized from solution in the shattered zone. The chromite formed was later shattered and secondary minerals were introduced into the cracks.

A few hundred feet down the valley below this chromite occurrence there is a loose boulder, 5 feet in diameter, of alternating bands of dunite and disseminated chromite. The chromite bands are about one-half inch in diameter and it appears that the chromite makes up about 25 per cent by volume of the rock. Each of the bands consists of well-shaped, thickly spaced crystals averaging one-tenth inch in diameter. Across the boulder are talc seams, at right angles to the chromite bands, with unaltered chromite crystals in the talc continuous with the chromite in the boulder. This boulder is of scientific interest regarding the origin of chromite and talc and its relation to dunite.

DARK RIDGE CHROMITE PROSPECT

The Dark Ridge chromite prospect in Jackson County, one and one-half miles southwest of Balsam Station, is associated with the Dark Ridge olivine deposits on Dark Ridge Creek. The chromite is best exposed in a pit about 900 feet east of the Southern Railroad trestle, north of the creek and north of the trail (see Plate 7).

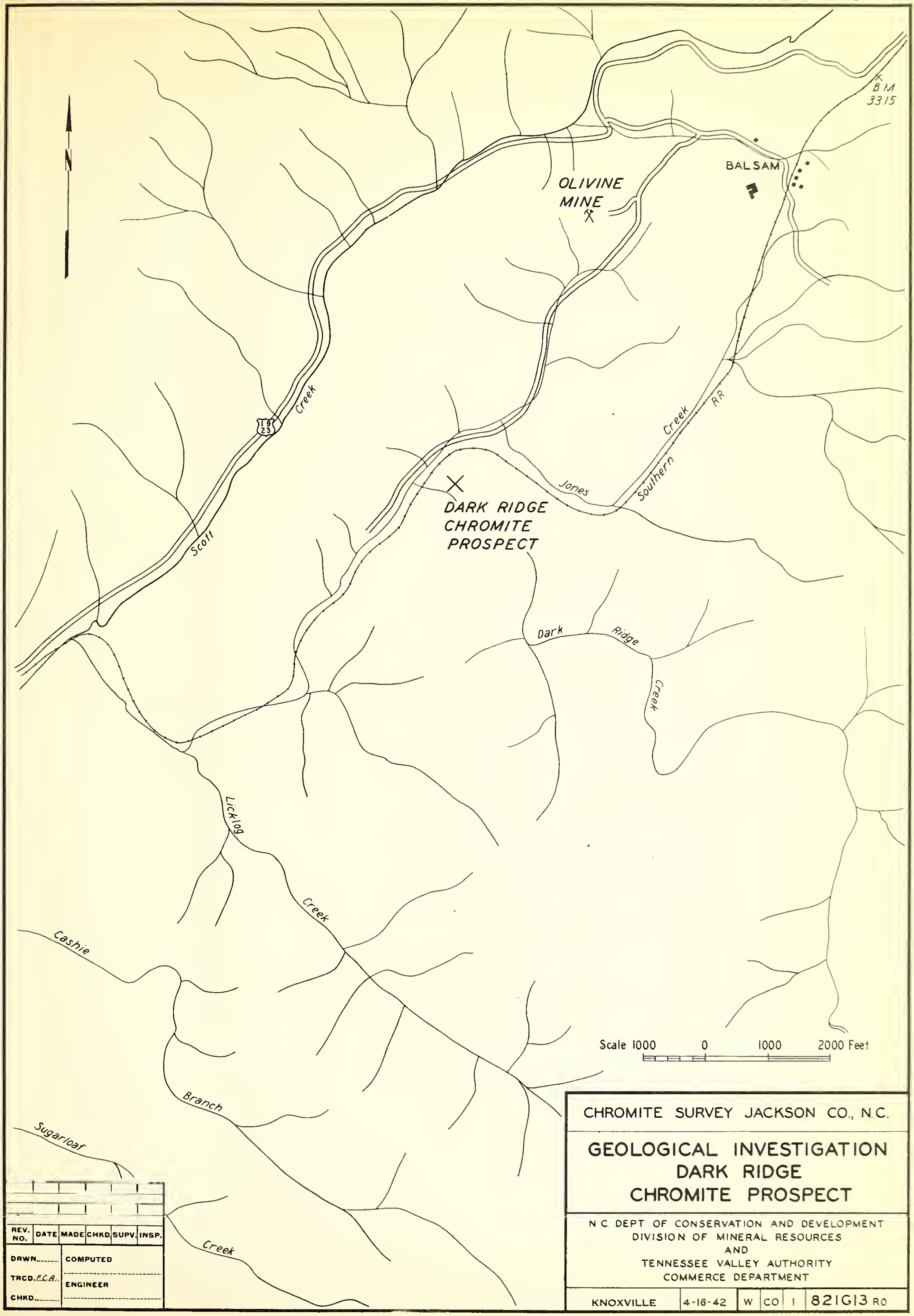
This pit, about 25 feet long, 12 feet wide, and 20 feet deep, was made about 1930. It is reported that less than 50 tons of chromite was taken out, including one solid lump weighing 250 pounds. A ton or more of chiefly massive and very black chromite partly banded with olivine remains on the dump. It is reported that the chromite encountered occurred as a vein-like lens with a maximum thickness of about two feet and prevailed to the bottom of the pit. At the present time the sides have slumped in sufficiently to about half fill the pit. Most of the chromite is in direct contact with sound olivine.

A chipped sample of chromite including matrix taken from the dump gave the following analysis:[1]

Cr_2O_3	Fe_2O_3	SiO_2	Al_2O_3	MgO	*Total*	*Cr:Fe*
39.66	14.18	7.20	26.80	12.34	100.18	2.7:1

1. Chemical analysis by W. A. Reid, Chemist, Division of Mineral Resources, N. C. Dept. of Conservation and Devel., Raleigh, N. C.

PLATE 7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CHROMITE SURVEY JACKSON CO., N.C.
GEOLOGICAL INVESTIGATION
DARK RIDGE
CHROMITE PROSPECT
N.C. DEPT OF CONSERVATION AND DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
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The chromite in this pit appears to have come from a fault zone which probably contains other similar lenses. Therefore, it is believed that further prospecting in the vicinity of the pit would be justified.

Almost directly across the creek from the pit described above there is a much older and smaller pit, which is now about filled and grown over. It is reported by local residents that a small pocket of chromite was uncovered in this pit. At the present time small fragments of chromite remain on the dump.

Almost due east of the first-described and largest pit, and 200 feet north of the trail, a few veins of chromite are exposed in the olivine ledges. The main exposure is a vein exposed for 15 feet in length and about 5 inches wide, which dips to the north and back into the hill. The hanging wall side consists of saxonite and the foot wall is of dunite. The chromite is composed of grains less than one-quarter inch in diameter with most of the grains separated by kammererite.

The chromite in the Dark Ridge deposit is associated with good sound olivine, and probably the best way to produce chromite from this deposit would be as a by-product from olivine production.

MACON COUNTY

CORUNDUM HILL CHROMITE PROSPECT

The Corundum Hill chromite prospect, which is associated with the Corundum Hill dunite formation,[1] is located one and one-half miles northwest of Gneiss, Macon County. This location is north of Cullasaja River and southeast of Evans Knob (see Plate 8). The southern quarter of the Corundum Hill formation contains disseminated chromite probably averaging about 2.5 per cent by volume. The chromite crystals, averaging less than one-quarter inch in diameter, are well shaped, are a dull, shiny black, and are in a matrix of sound olivine.

The southern slope of Corundum Hill, an area of two or three acres, contains residual chromite crystals and fragments derived from weathering of the dunite. The overburden is rather thin over the dunite and in places the bare rock is exposed at the surface. This overburden of clay probably averages three feet in thickness and appears to contain about 5 per cent chromite.

The small stream heading near the deposit contains small amounts of chromite and corundum in about equal proportions, in places up to 25 per cent. The material occurs in the bottom of the stream and along the sides back for a distance of about 30 feet. In this stream the corundum might prove more valuable than the chromite.

The following results were obtained on a 100 pound sample of the placer material taken from the creek bottom:[2]

+20 Mesh Concentrate		*—20 Mesh Concentrate*	
Cr_2O_3	43.33%	Cr_2O_3	38.59%
Fe	23.78	Fe	29.31
Insol.	11.48	Insol.	9.20
Cr:Fe	1.2:1	Cr:Fe	0.8:1

1. Hunter, Charles E., and Mattocks, Philip W., "Vermiculites of Western North Carolina and North Georgia," Tennessee Valley Authority, Division of Geology, Bulletin No. 5 (1936) p. 1.
2. Beneficiation and chemical analysis made by Tennessee Valley Authority Minerals Testing Laboratory, Norris, Tennessee.

A number of small pieces of massive chromite float have been found along the northern contact area.

ELLIJAY CHROMITE PROSPECT

The Ellijay chromite prospect (Olivine Deposit Number Nine)[1] is located on Ellijay Creek three-fourths mile southwest of Ellijay Post Office, Macon County. The chromite is best exposed on the south side of a hill about 1,200 feet east of Ellijay Creek in an outcrop of high-grade sound olivine (see Plate 8). The prospect uncovered a small lens of massive chromite which was mined during, or shortly after, the war of 1917-18. The opening is about 40 feet long, 6 feet wide, and 15 feet deep. The chromite lens is reported to have been about 2 feet wide and 12 feet long. Small veins of chromite, approximately 2 inches in width, are visible in the side of the cut. The chromite found on the dump consists of fine-grained material with occasional crystals one-quarter inch in diameter. Talc and chlorite are found between the grains. The massive vein type of ore shows little indication of alteration.

There is a small amount of disseminated chromite in the dunite on the opposite side of the hill from the pit.

NORTON CHROMITE PROSPECT

The Norton chromite prospect occurs one mile west of Orlando, Macon County. The dunite formation with which the chromite is associated lies on the north side and adjacent to Commissioner Creek (see Plate 4). The formation has been greatly altered to amphibolite and outcrops as a steep, but rounded, hill sloping southward toward the creek. The southwestern part of the formation contains crystals and blebs of chromite visible all the way to the crest of the hill. Near the west contact there is a small amount of magnetite mixed with the chromite.

It is doubtful if there is sufficient concentration of chromite at any one place in the formation to permit economical exploitation. However, there may be enough residual chromite on part of the weathered surface from which a few hundred tons of chromite could be recovered.

IREDELL COUNTY

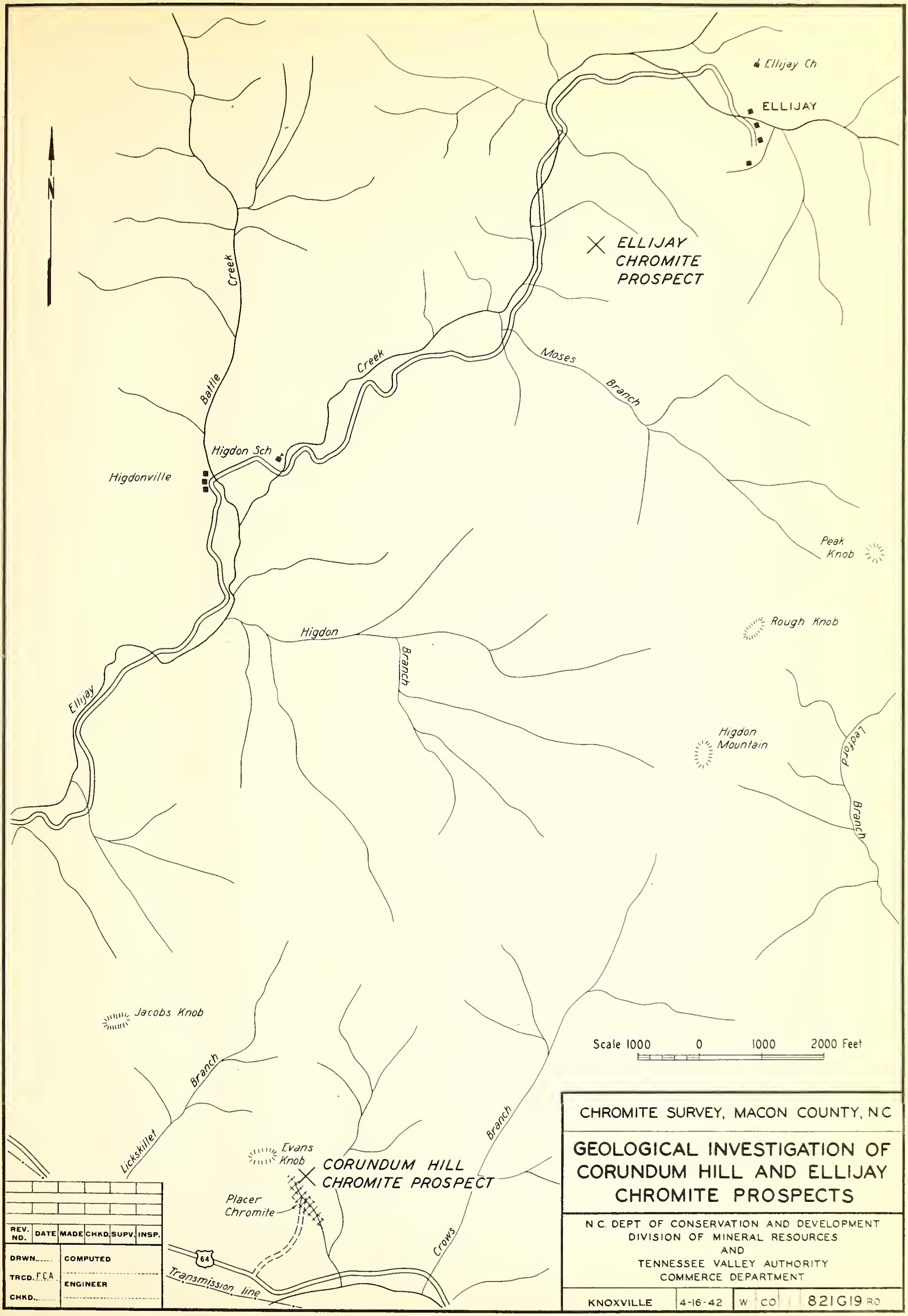
PLYLER CHROMITE PROSPECT

The Plyler chromite prospect is located about seven miles northeast of Statesville, Iredell County. The occurrence, primarily on the Plyler farm one and one-half miles south of Turnersburg, is on the south side of the South Fork of Yadkin River. This prospect is in the Piedmont area and is about 100 miles east of the other chromite deposits of the State.

The chromite is associated with a large and highly serpentinized dunite mass. The formation does not form rough or hilly topography as do the basic ones in the western part of the State, but underlies broad low knolls typical of the surrounding country.

The chromite occurs mainly in the northeastern part of the formation and is best exposed a few hundred feet south of the Yadkin River. At this point there has been some

1. Hunter, Charles E., "Forsterite Olivine Deposits of North Carolina and Georgia," N. C. Dept. Cons. and Devel. Bull. No. 41 (1941) p. 100.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Ledford Branch
Jacobs Knob
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CHROMITE PROSPECTS
N C. DEPT OF CONSERVATION AND DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
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recent open-pit prospecting at points where there were showings of chromite. The pits are about 40 by 50 feet, much larger than the area of exposed chromite. The material taken out and stocked averages about 15 per cent chromite. Probably about 100 tons of this disseminated ore was removed from the cuts, which is a very small proportion to the amount of material handled. No attempt was made to follow down on the richer chromite showing of disseminated or vein material. Most of the chromite encountered was disseminated ore that contains both chromite and magnetite in a gangue of talc, chlorite, and serpentine. The small irregular disseminated chromite zones are too irregular and not closely enough connected to mine.

OTHER CHROMITE LOCALITIES

There are several other minor occurrences of chromite in western North Carolina. None of these are thought to be of any commercial importance.

Chromite is reported on Cove Creek about seven miles northwest of Boone, Watauga County, and in the vicinity of Sapphire, Jackson County.

Disseminated chromite in olivine occurs on White Oak Creek, one mile southeast of Bakersville, Mitchell County. Crystals and blebs of chromite up to one-half inch in diameter are visible in much of the olivine exposed on the south side of White Oak Creek.

MAGNETIC GEOPHYSICAL SURVEY OF THE WEBSTER AND DEMOCRAT, N. C., CHROMITE AREAS

After the principal chromite deposits of North Carolina were examined in detail, parts of the Webster and Democrat areas were selected for investigation by geophysical methods. These two areas appeared to offer more promise than the other areas for locating concealed chromite ore bodies. Through the cooperative agreement between the North Carolina Department of Conservation and Development and the Tennessee Valley Authority, the services of Dr. Gerald R. MacCarthy, Professor of Geology, University of North Carolina, were obtained for conducting the magnetic geophysical survey. The following report by Dr. MacCarthy covers this survey.

INTRODUCTION

The author alone is responsible for the data and opinions set forth in this section of the report. Special thanks, however, are due to Dr. F. W. Lee and to Dr. J. H. Swartz of the United States Geological Survey, who offered many helpful suggestions, especially in regard to the interpretation of the data.

GEOPHYSICS

Geophysics may be defined as the application of physics to the solution of geological problems. Every rock and mineral species has certain physical properties which, while more or less constant for each species, differ considerably from one species to another. Among these physical properties are density (or specific gravity), elasticity, electrical conductivity, and magnetic permeability. Each of these properties has been used as the basis of a specific method of geophysical prospecting.

Seismic prospecting, widely used in the petroleum industry, is based upon the elastic properties of earth materials. Gravitational prospecting is also much used by the oil industry. It is based upon density differences. Electrical prospecting is based upon differences in rock conductivities, upon the presence of natural earth currents, and the like. Magnetic prospecting is based upon differences in the magnetic susceptibility of the different rocks and minerals.

No geophysical method—used by itself—can be relied upon to give a complete and accurate picture of underground conditions. In all cases the geophysical data must be supplemented by, and studied in connection with, geological data. The combination of geology and geophysics always proves to be a far more accurate tool than either method used alone.

Magnetic Methods

All substances are more or less magnetic, although only iron, cobalt, and nickel, together with certain of their compounds, are strikingly so. Were the materials composing the crust of the earth entirely uniform in their magnetic properties, the earth's magnetic field would also be uniform, and would change from one place to another in a perfectly regular fashion. But, because of the varying magnetic properties of the rocks and minerals which make up the earth's crust, the earth's magnetic field is not at all uniform. In fact, it is highly irregular. Since these local magnetic irregularities or "anomalies" are caused by the presence of different rocks and minerals in a given region, a study of the magnetic anomalies frequently will give a clue to the geology of the region.

For certain technical reasons the total strength of the earth's field is rarely determined, usually only changes in the intensity of its vertical component are measured by field magnetometers.

Magnetic anomalies are of two general kinds. A rock formation or ore body which has a higher magnetic susceptibility than that of the surrounding material will cause a magnetic "high" by intensifying the earth's field in its immediate neighborhood, while one possessing a lower than average susceptibility will cause a magnetic "low". Polarized formations are also found. Such formations are not simply magnetic; they have been magnetized so that they behave as though they were actual bar magnets and exhibit definite north and south poles. An example of such a polarized formation is found on the map of the North Part of the Democrat Chromite Area with the positive pole near coordinates B: 4.25, and the negative pole near coordinates B: 3.10 (see Plate 17).

It should be noted that while magnetic anomalies serve to locate the position of underground features quite accurately as far as their geographic position goes, it is often difficult to distinguish between a small magnetic disturbance close to the surface and a large one at a greater depth. In this respect magnetic and electrical prospecting serve to complement each other, for while the various methods based upon electrical conductivity frequently give accurate *depth* determinations, they do not, as a rule, fix the geographical position as closely as does the magnetic method. When dealing with an occurrence which gives both magnetic and electrical indications, the ideal method of attack would be to locate first the geographical position of the anomalies by means of the magnetometer, and then resurvey certain selected portions of the field by electrical means. Unfortunately, any of the electrical methods requires far more apparatus, demands a larger crew of men, and is much more expensive than a magnetic survey of the same area. For these reasons no electrical work has been done so far in the North Carolina chromite areas.

Chromite, which is somewhat variable in its chemical composition, is also variable in its magnetic behavior, since the latter depends, to a large extent, upon the former. Some specimens are quite magnetic, while most of them are less magnetic than the rocks in which they are found. Chromite may therefore give rise either to magnetic "highs" or to magnetic "lows", although the latter is the more usual case. This is because *dunite*, the rock with which chromite is almost always associated, is in itself extremely magnetic for a rock. Even when the chromite differs too little in susceptibility from the surrounding rock to give usable anomalies, the bodies of intrusive rock in which the chromite deposits are located may be outlined by means of the magnetometer although concealed by many feet of overburden. This is especially well shown in the Webster chromite area. A comparison of the geologic map (see Plate 9) with either the cardboard model (see Plate 10) or the "isogamic" map (see Plate 13) shows that the contacts of the dunite intrusion with the surrounding country rock were located by the magnetometer with great accuracy, as was the presence of such features as a large quartz vein, and other bodies of quartz and talc whose presence was confirmed by "float".

The following table shows the magnetic susceptibilities[1] of certain rocks and minerals.[2] The mineral magnetite has a susceptibility of about 300,000 x 106 units.

Rock or Mineral	*Magnetic Susceptibility*
Quartz	—1.07 to —1.2
Serpentine	10.87
Ilmenite	30,740 to 252,000
Chromite (Asia Minor)	244.51
Hematite	40 to 100
Limonite	100 to 220
Gneiss (various)	10 to 2000
Talcose slate (Urals)	3000
Pyrrhotite (Sudbury)	125,000
Serpentine (Harz)	254
Serpentine (Urals)	14,100
Schist (Oberharz)	115

Magnetite, pyrrhotite, and ilmenite are the only *extremely* magnetic minerals commonly met with. While both magnetite and ilmenite were seen, no pyrrhotite was recognized during these investigations.

In most cases it is the amount of magnetite or ilmenite contained in a rock which governs its susceptibility and, since many of the igneous and metamorphic rocks vary greatly from specimen to specimen in the amount of these minerals which they carry, no one figure for susceptibility can be applied to all specimens of the same rock type.

In both the Webster and the Democrat areas the chromite is associated with the rock *dunite.* Dunite is a more or less pure olivine rock, usually containing scattered crystals of either magnetite or chromite. In North Carolina much of the dunite has been partially altered to *serpentine,* and therefore, from the table above, we may take its magnetic susceptibility as ranging somewhere between 254 and 14,100 units. Chromite, as listed in the table, has a susceptibility of only 245 units, and hence is *definitely* less magnetic than the rock with which it is intimately associated. A chromite ore body should therefore show on a magnetic map as a weak "low", and this relation was noted in all cases where the presence of chromite has been definitely proved. If we were dealing with serpentinized dunite and chromite alone, without the further complication of the presence of such highly magnetic materials as magnetite and ilmenite, it should be easy to locate all chromite ore bodies with little trouble. But such is not the case; both at Webster and at Democrat the picture is confused by the presence of these highly magnetic minerals which more or less mask the presence of the weakly magnetic chromite. Therefore only those chromite ore bodies which are not too closely associated with magnetite or ilmenite can be recognized as such by magnetic means.

An example of a magnetic high caused by the mineral magnetite may be seen on the "isogamic" map of the southeast part of the Webster area. The small but intense high located near coordinates D-40: 1.25 was excavated, and a quantity of chlorite schist containing visible dense, black crystals found. The black crystals were later found to be

1. Magnetic susceptibility is merely a numerical expression indicating how magnetic a given substance is. For present purposes it is sufficient to remember that the higher the value of the susceptibility, the more magnetic the material.
2. As given by C. A. Heiland in "Geophysical Exploration," New York: Prentice-Hall, 1940, pp. 310 *et seq.*

magnetite and ilmenite, with the latter predominating. The chlorite schist, when crushed and panned, furnished slightly more than 5 per cent of heavy minerals, of which about 20 per cent appeared to be magnetite and the rest ilmenite. Chromite could not have been present in any appreciable quantity, since no chromium reaction was obtained either from the crystals or from the rock itself.[1]

In both the Webster and the Democrat areas every known occurrence of chromite gives rise to a weak magnetic low. Unfortunately, these lows are by no means the most striking features of the magnetic picture. Nevertheless, they are distinct enough and form sufficiently definite patterns to indicate with a considerable degree of probability both the further extension of known ore bodies, and the possible existence of hitherto undiscovered pockets of chromite. The presence of a weak magnetic low, similar to the lows which occur in association with known bodies of chromite, does not *prove* the existence of a chromite pocket beneath it; it merely indicates that such an area is worthy of further investigation, and that it should be trenched or drilled. Where no such lows are present the probability of chromite being present is very slight, and further investigations of such areas should be postponed until all the more favorable localities have been tested.

PROCEDURE

In both the Webster and Democrat areas rectangular grids were laid out by means of the transit. Magnetometer readings were taken at definite intervals along these coordinate lines. Over much of the area readings were also taken along more closely spaced lines, parallel to those of the main grid. These grids are described in more detail by T. G. Murdock.[2]

No attempt was made to reduce the magnetometer readings to their absolute values. Instead, a station was arbitrarily chosen as the base station, its value assumed to be zero, and all readings referred to it. Thus, if "800 gammas" is recorded for a certain station, it is to be understood that the reading at that station was 800 gammas higher than at the base station, with no implication of the absolute value at either point. Likewise, a recorded value of "minus 1,000 gammas" merely means that at that point the reading was 1,000 gammas lower than at the base station.

All readings were taken by means of the Askania "Schmidt Type Vertical Field Balance", and were reduced to gammas[3] before being plotted. For purposes of further study the data obtained in each of the three areas were used in the construction of three dimensional models of the "egg-crate" type. (See photographs of these models, Plates 13, 14, 15, 18, and 20). Each magnetic traverse was plotted on cross-section paper, using the same horizontal scale as was used in constructing the geologic maps, transferred to stiff cardboard, and the latter cut to follow the plotted curves. These cardboard strips, when set up along the lines of the traverses, form the models. Several "isogamic maps" were also constructed to illustrate portions of the areas in a more familiar manner. An

1. Determinations made by William Rice of the University of North Carolina.
2. Murdock, T. G., "Horizontal Control—Webster and Democrat, N. C. Chromite Investigation," R. I. 24 and 25, Division of Mineral Resources, N. C. Dept. of Conservation and Development, Raleigh, N. C.
3. A gamma is the one-hundred thousandth of the *gauss*, the fundamental magnetic unit. The total strength of the earth's field is about 50,000 gammas, or half a gauss, so that an anomaly of 10,000 gammas means a local variation in the earth's field of one part in five, or 20 percent.

isogamic map is similar to the familiar "contoured" topographic map, except that the "contour lines" are drawn through points of equal magnetic readings instead of through points of equal elevation above sea level as is done in constructing a topographic map. (See Plate 10.)

WEBSTER AREA

MAGNETIC SURVEY

Plate 9 is a geologic map of the area near Webster, North Carolina, which was surveyed; Plates 10, 11, and 12 are isogamic maps of portions of the same area; and Plates 13, 14, and 15 are photographs of the egg-crate model.[1] The general features of the area are perhaps best exhibited by the model. Along the northern margin of the model the flat "magnetic plateau" indicates the presence of the rather homogeneous schists which occupy that area. South of the schists is an irregular linear high which extends across the model in a roughly east-west direction. This "contact high" lies along the northern boundary of the dunite intrusion and is apparently caused by the presence of iron-bearing minerals concentrated along the contact zone. Only weathered specimens were available for study, and the predominant iron mineral was *limonite.* The limonite, which is only weakly magnetic, was doubtlessly formed by the alteration of magnetite or ilmenite still present at greater depths, as is indicated by the high magnetic readings obtained along this contact zone. A less continuous but still well-marked low which lies between the schists and the contact high follows in part a zone of talc and in part a rather wide vein of massive quartz.

The relatively featureless southern margin of the model represents the rather uniform hornblende gneiss and schists which border the dunite in that direction and, especially in the southeast portion of the model, another contact high, similar to the one along the north border, indicates a discontinuous zone of magnetic chlorite and amphibolites which separates the gneisses from the dunite. An extremely magnetic mass of chlorite, whose magnetism is derived from the contained magnetite and ilmenite, was found to underlie the enormous high which stands out so prominently near the southeast corner of the model. (See Page 41.)

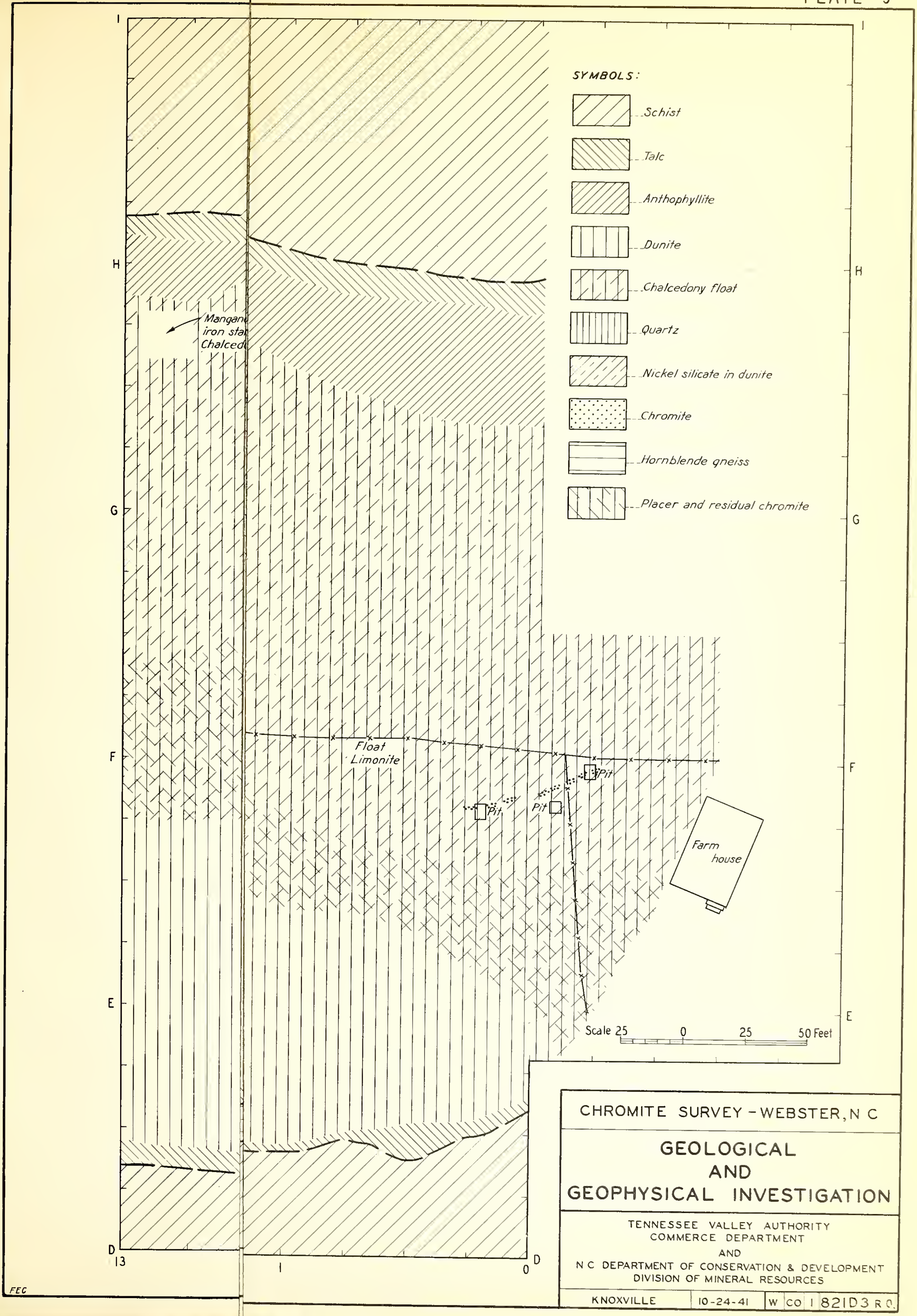
The dunite intrusion with which the chromite is associated occupies the central and less strikingly irregular portion of the model between the two contact highs.

Exact comparison of the geologic map and the magnetic model can best be made by actually superimposing the model directly upon the map. However, by carefully noting the map coordinates of the various features, more or less exact comparisons can be made from the illustrations accompanying this report.

Each of the maps, as well as the model, carries the same set of coordinates. The main north-south lines of the grid, 100 feet apart, are numbered consecutively from east to west, 0 to 13. The intermediate north-south lines, spaced 25 feet apart, are given the number of that main line of the grid which lies immediately to their east, plus a decimal indicating the number of feet separating them. Thus line 2.25 is that intermediate line which is parallel to, and 25 feet west of line 2 of the main grid; line 12.75 is the one which is

1. Geologic maps were made by Charles E. Hunter; models and isogamic maps were made by G. R. MacCarthy.

PLATE 9



SYMBOLS:
Schist
Talc
Anthophyllite
Dunite
Chalcedony float
Quartz
Nickel silicate in dunite
Chromite
Hornblende gneiss
Placer and residual chromite
Float
Limonite
Pit
Pit
Pit
Farm house
Scale 25 0 25 50 Feet
I
H
G
F
E
D
13
1
0
FEC
CHROMITE SURVEY - WEBSTER, N C
GEOLOGICAL
AND
GEOPHYSICAL INVESTIGATION
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT
AND
N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
KNOXVILLE
10-24-41
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WEBSTER AREA

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The relatively featureless southern margin of the model represents the rather uniform hornblende gneiss and schists which border the dunite in that direction and, especially in the southeast portion of the model, another contact high, similar to the one along the north border, indicates a discontinuous zone of magnetic chlorite and amphibolites which separates the gneisses from the dunite. An extremely magnetic mass of chlorite, whose magnetism is derived from the contained magnetite and ilmenite, was found to underlie the enormous high which stands out so prominently near the southeast corner of the model. (See Page 41.)

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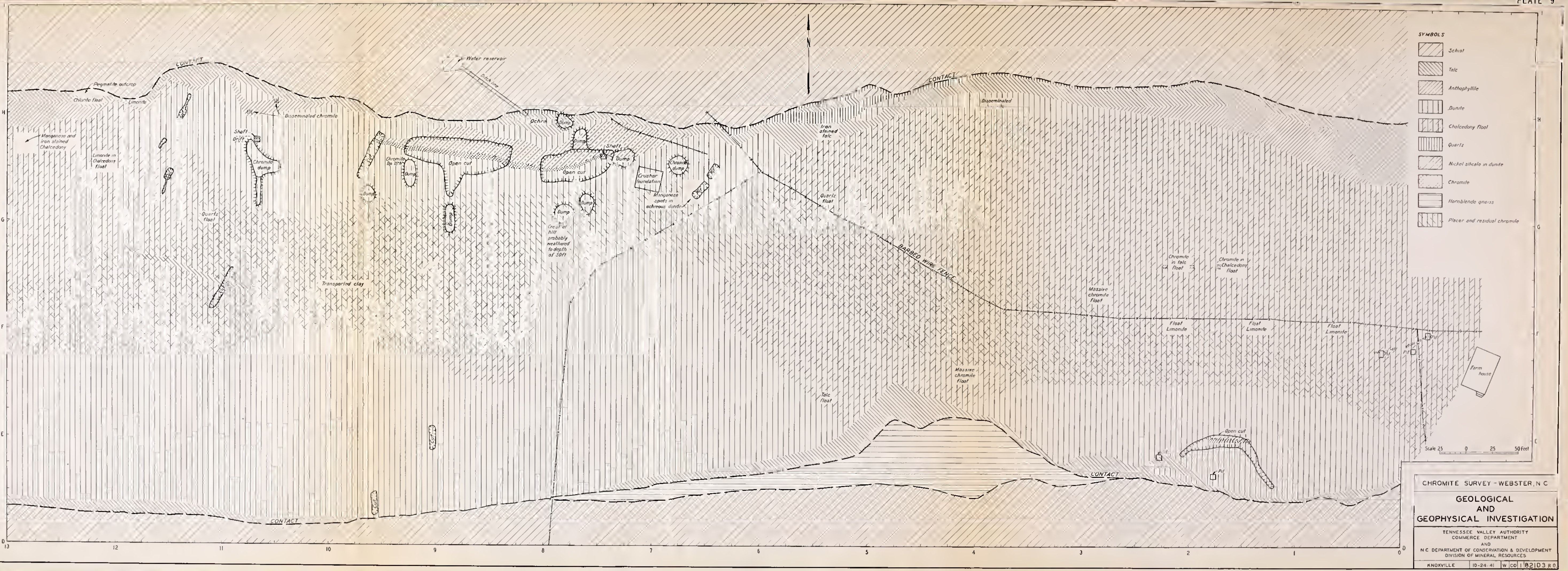
1. Geologic maps were made by Charles E. Hunter; models and isogamic maps were made by G. R. MacCarthy.


SYMBOLS
Schist
Talc
Anthophyllite
Dunite
Chalcedony float
Quartz
Nickel silicate in dunite
Chromite
Hornblende gneiss
Placer and residual chromite
Scale 25 0 25 50 Feet
CONTACT
Pegmatite outcrop
Chlorite float
Limonite
Water reservoir
Ditch line
Disseminated chromite
Manganese and iron stained Chalcedony
Limonite in Chalcedony float
Shaft
Drift
Chromite dump
Open cut
Dump
Ochre
Shaft
Crusher foundation
Chromite dump
Manganese spots in ochreous dunite
Crest of hill probably weathered to depth of 30ft
Quartz float
Transported clay
Iron stained talc
Quartz float
Disseminated
BARBED WIRE FENCE
Massive chromite float
Chromite in talc float
Chromite in Chalcedony float
Float Limonite
Float Limonite
Float Limonite
Pit
Farm house
Talc float
Massive chromite float
Open cut
Pit
13
12
11
10
9
8
7
6
5
4
3
2
1
0
H
G
F
E
D
CHROMITE SURVEY - WEBSTER, N C
GEOLOGICAL AND GEOPHYSICAL INVESTIGATION
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT
AND
N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
KNOXVILLE
10-24-41
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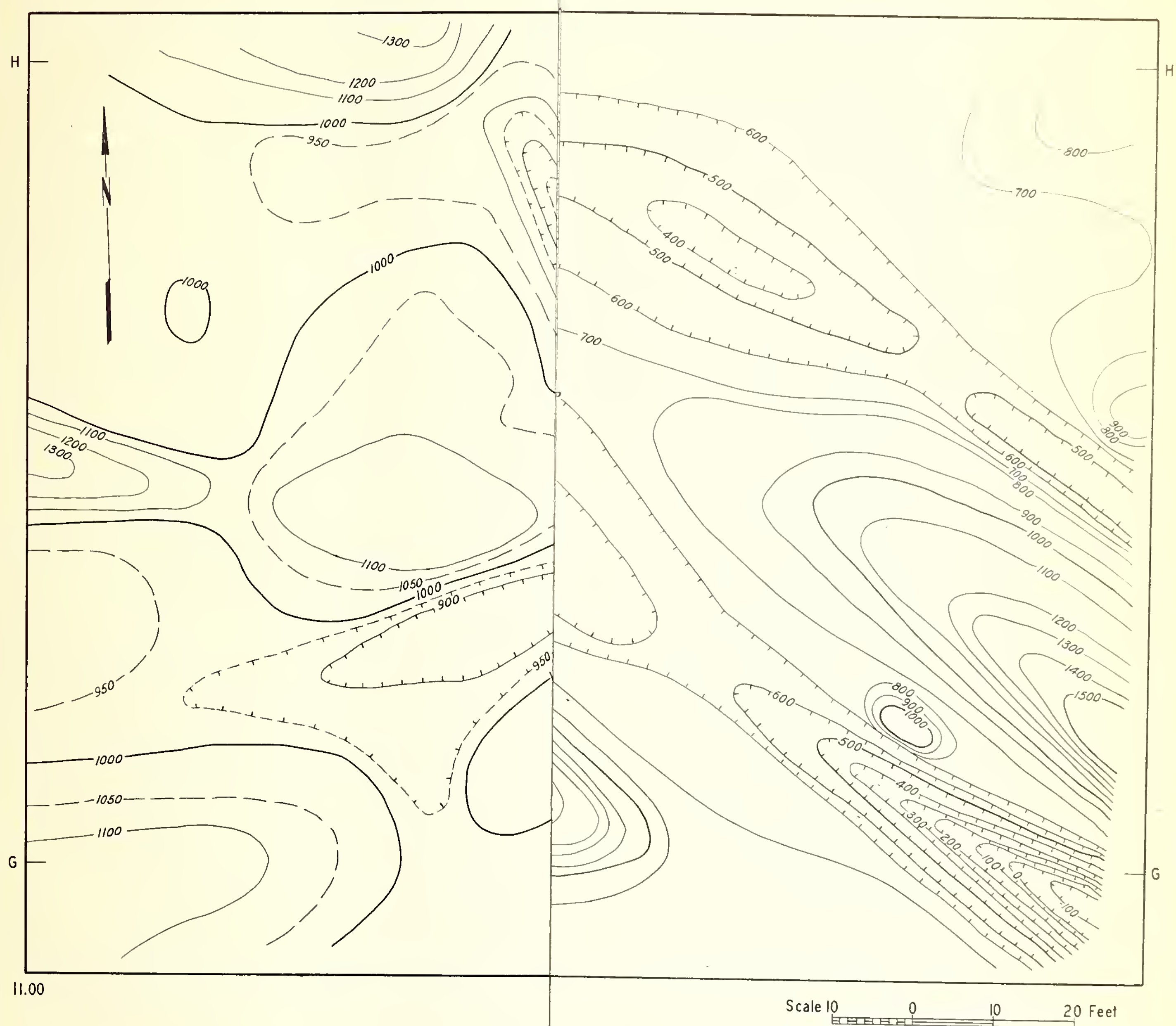

CHROMITE SURVEY - WEBSTER, N C

GEOPHYSICAL INVESTIGATION
MAGNETIC MAP

N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

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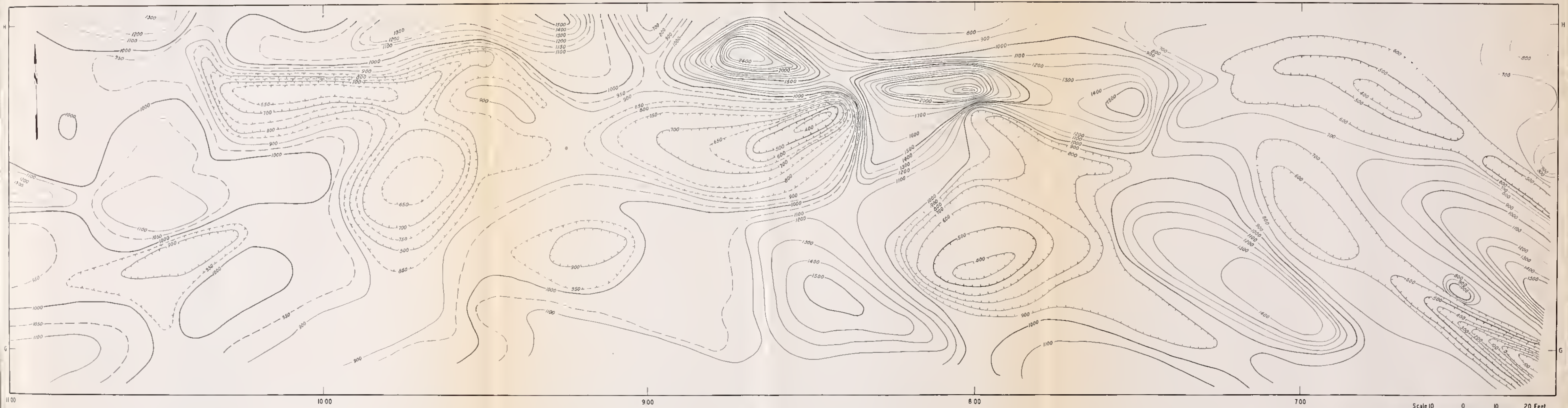
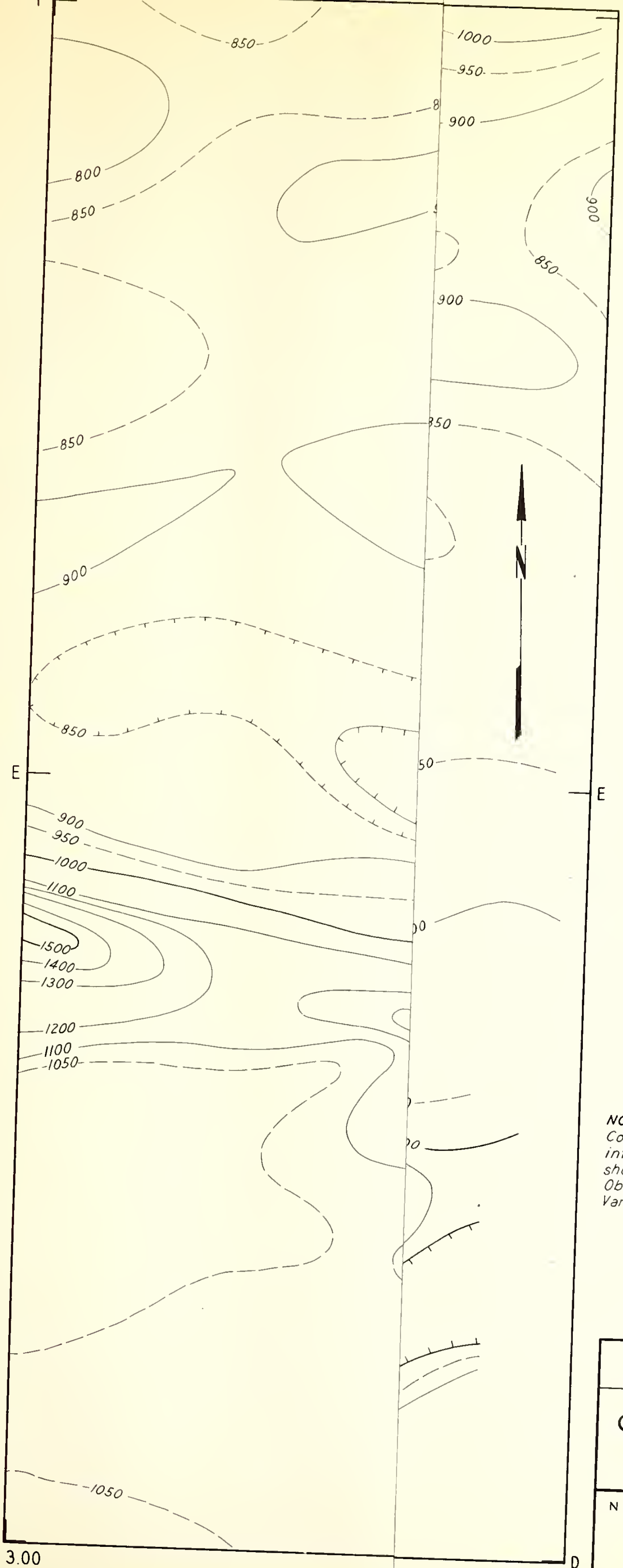


NW PART OF WEBSTER, N C CHROMITE AREA

NOTES:
Contours are isogams drawn at 50 and 100 gamma. Where used, 50 gamma intervals are shown by dashed lines
Observations were made with Askania Vertical Variometer.

CHROMITE SURVEY - WEBSTER, N C
GEOPHYSICAL INVESTIGATION MAGNETIC MAP
N C DEPARTMENT OF CONSERVATION & DEVELOPMENT DIVISION OF MINERAL RESOURCES AND TENNESSEE VALLEY AUTHORITY COMMERCE DEPARTMENT
KNOXVILLE | 11-3-41 | W | CO | 1 | 821 D 4 - 11



NOTES:
Contours are isogams drawn at 50 and 100 gamma intervals. Where used, 50 gamma contours are shown by dashed lines.
Observations were made with Askania Vertical Variometer.

Scale 10 0 10 20 Feet

CHROMITE SURVEY-WEBSTER, N. C.
GEOPHYSICAL INVESTIGATION MAGNETIC MAP
N C DEPARTMENT OF CONSERVATION & DEVELOPMENT DIVISION OF MINERAL RESOURCES AND TENNESSEE VALLEY AUTHORITY COMMERCE DEPARTMENT
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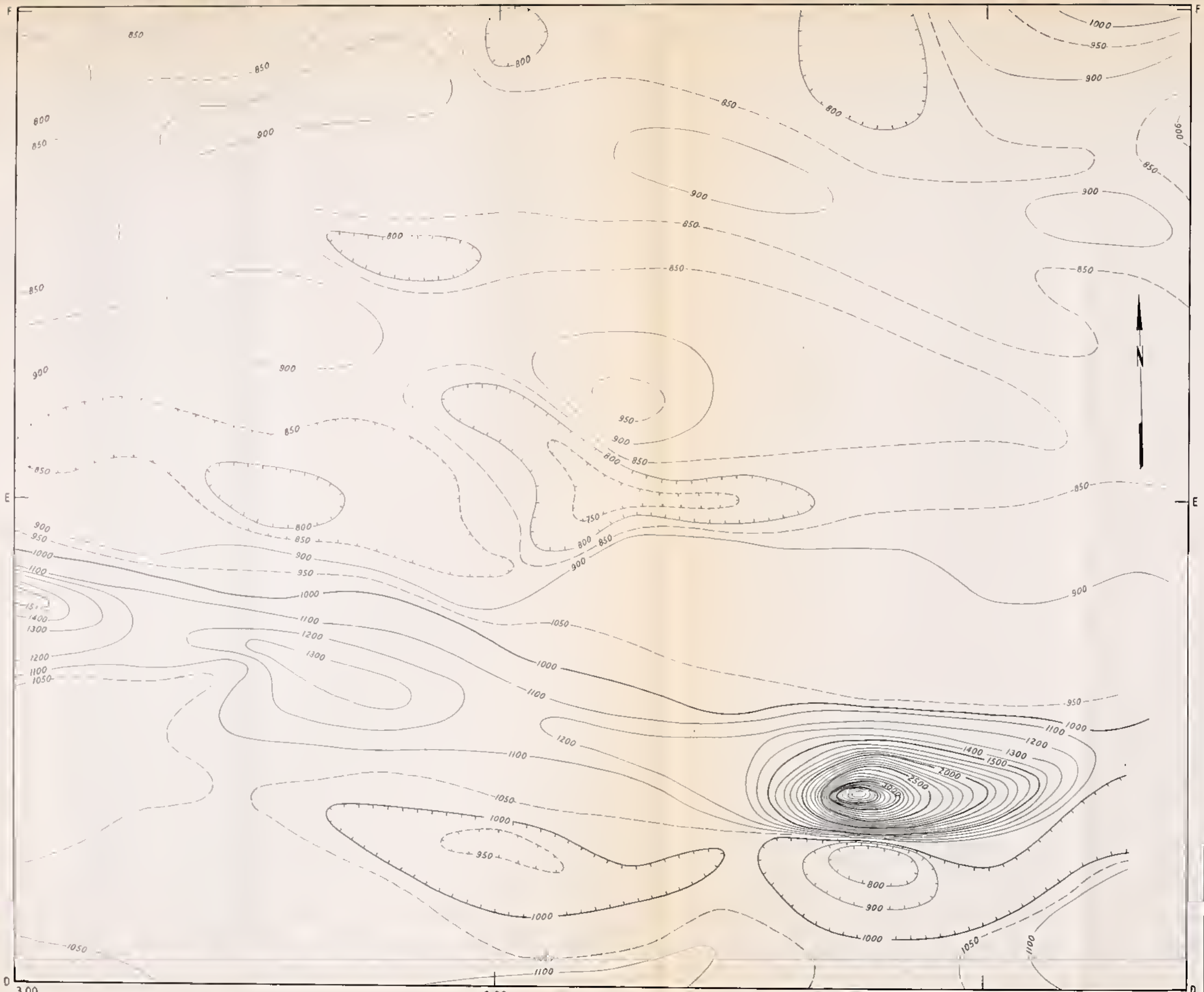


SOUTHEAST PART OF WEBSTER N C CHROMITE AREA

NOTES
Contours are isogams drawn at 50 and 100 gamma intervals. Where used, 50 gamma contours are shown by dashed lines.
Observations were made with Askania Vertical Variometer.

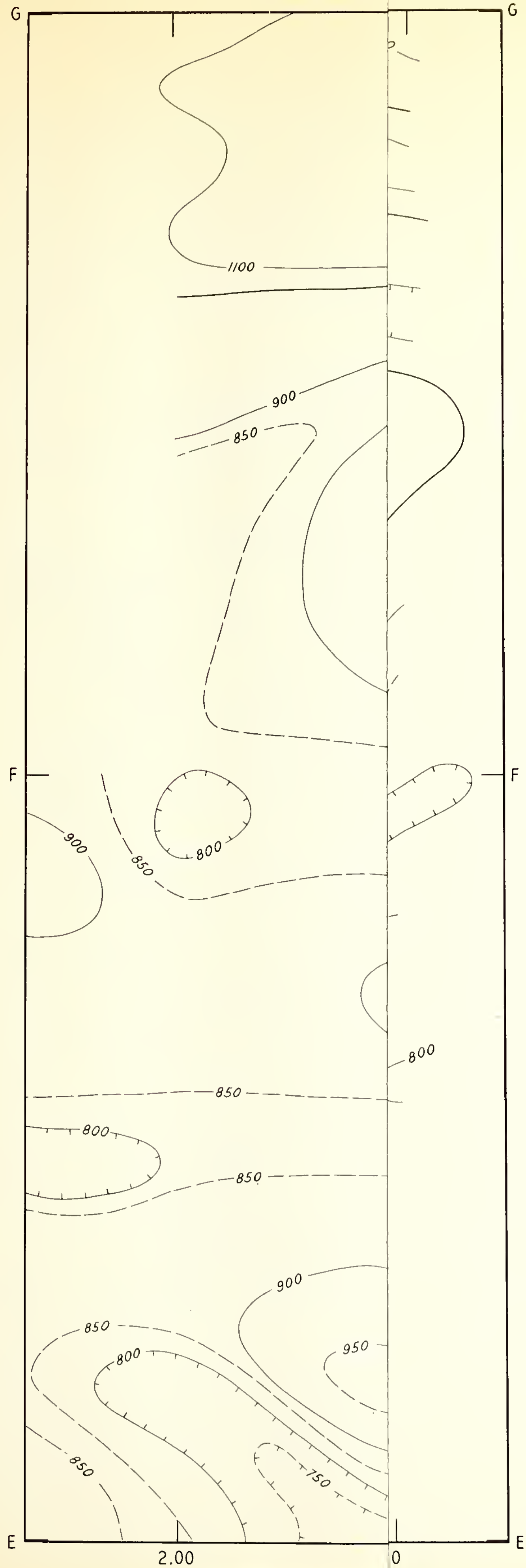
Scale 10 0 10 20 Feet

CHROMITE SURVEY-WEBSTER, N.C.

GEOPHYSICAL INVESTIGATION MAGNETIC MAP

N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

KNOXVILLE	1-2-42	W	CO	1	821B4-2 R O



NOTES:
Contours are isogams drawn at 50 and 100 gamma intervals. Where used, 50 gamma contours are shown by dashed lines.
Observations were made with Askania Vertical Variometer

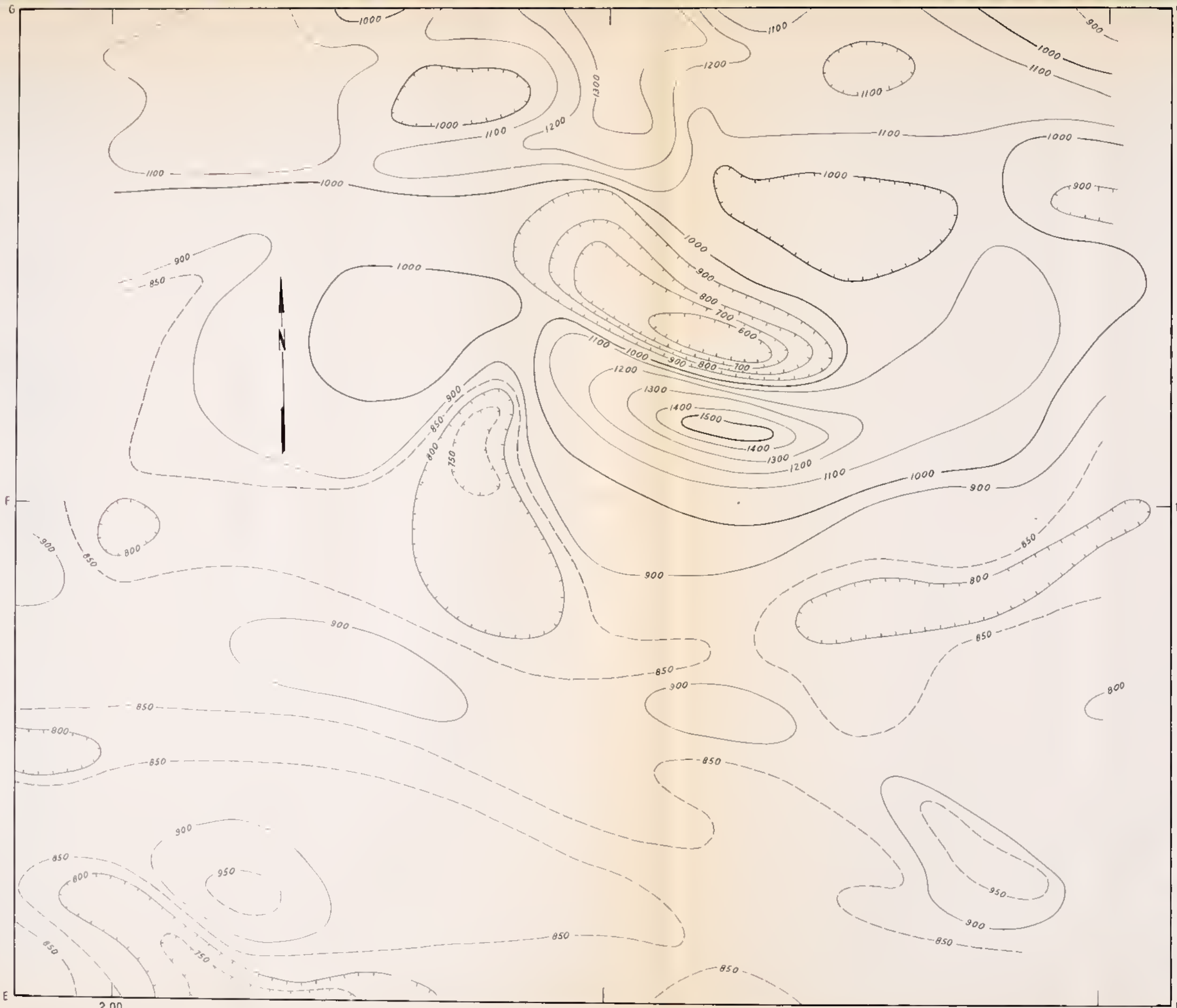
Scale 10 0 10 20 Feet

CHROMITE SURVEY-WEBSTER, N.C.

GEOPHYSICAL INVESTIGATION
MAGNETIC MAP

N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

KNOXVILLE	1-2-42	W	CO	I	821B4-3RO



NORTHEAST PART OF WEBSTER N. C. CHROMITE AREA

NOTES·
Contours are isogams drawn at 50 and 100 gamma intervals. Where used, 50 gamma contours are shown by dashed lines.
Observations were made with Askania Vertical Variometer

Scale 10 0 10 20 Feet

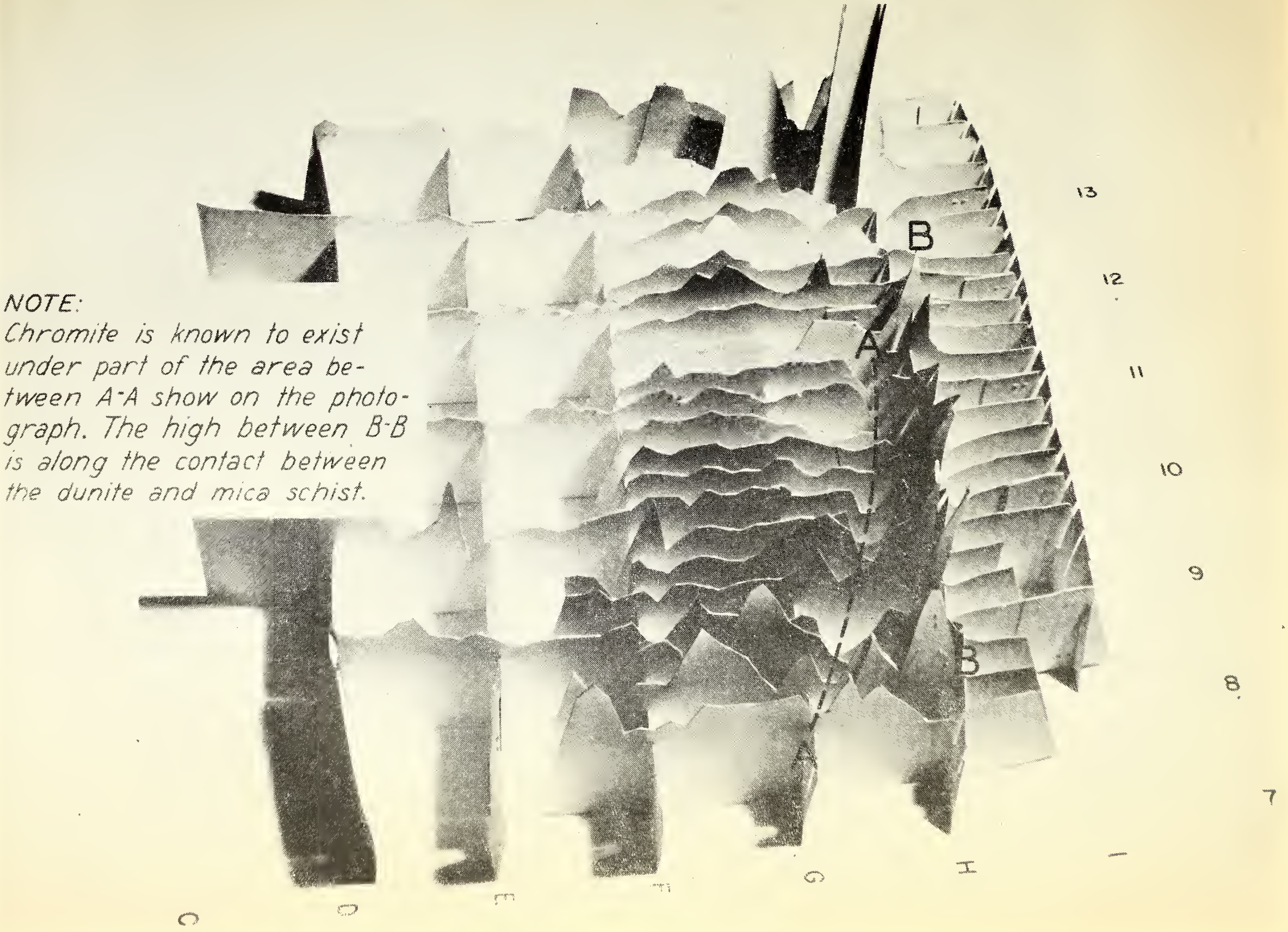
CHROMITE SURVEY-WEBSTER, N. C.

GEOPHYSICAL INVESTIGATION
MAGNETIC MAP

N. C. DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

KNOXVILLE	1-2-42	W	CO	1	821B4-3 RO

MAGNETIC RELIEF MODEL
N.W. PART OF WEBSTER, N.C. CHROMITE AREA



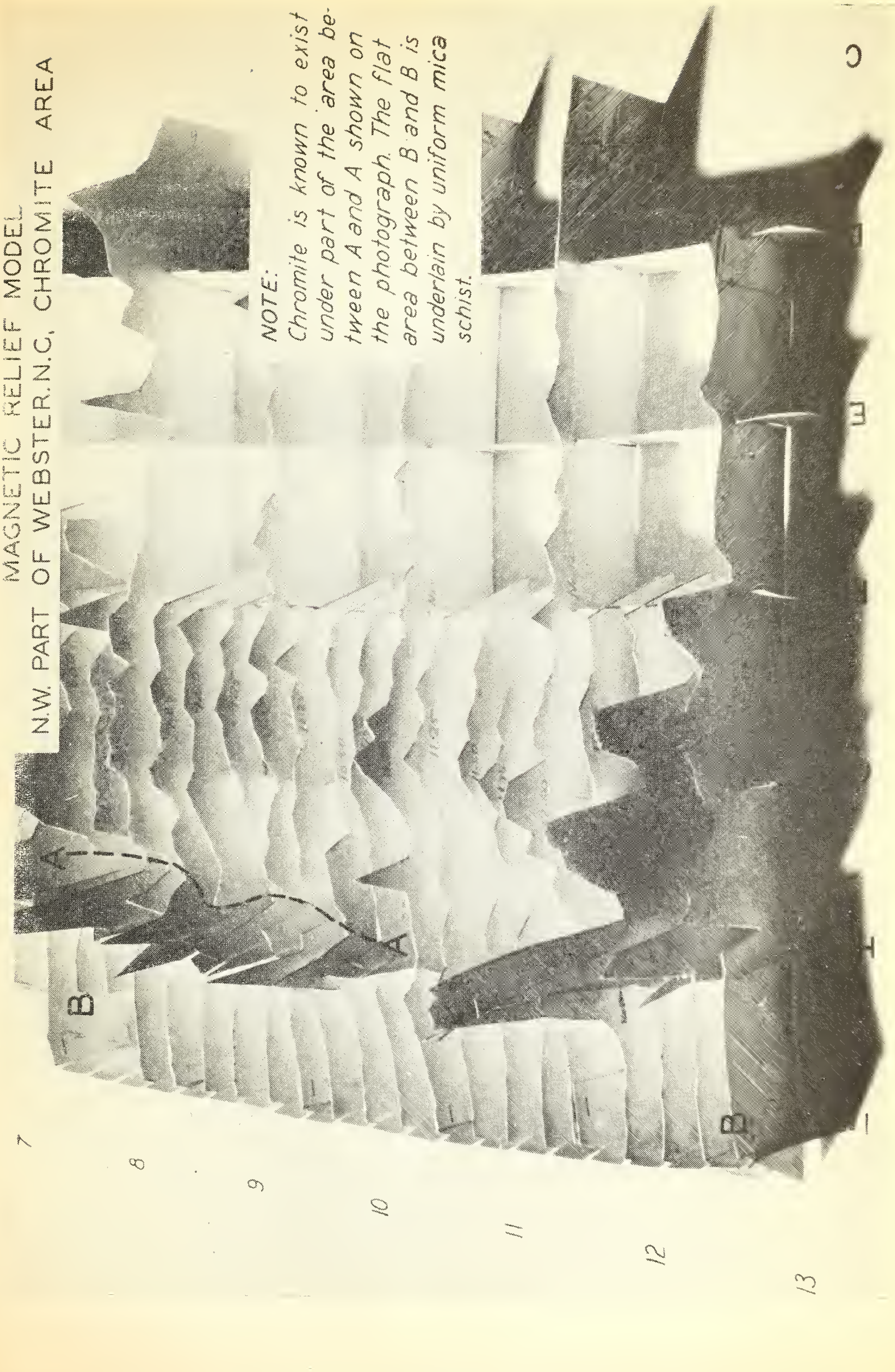
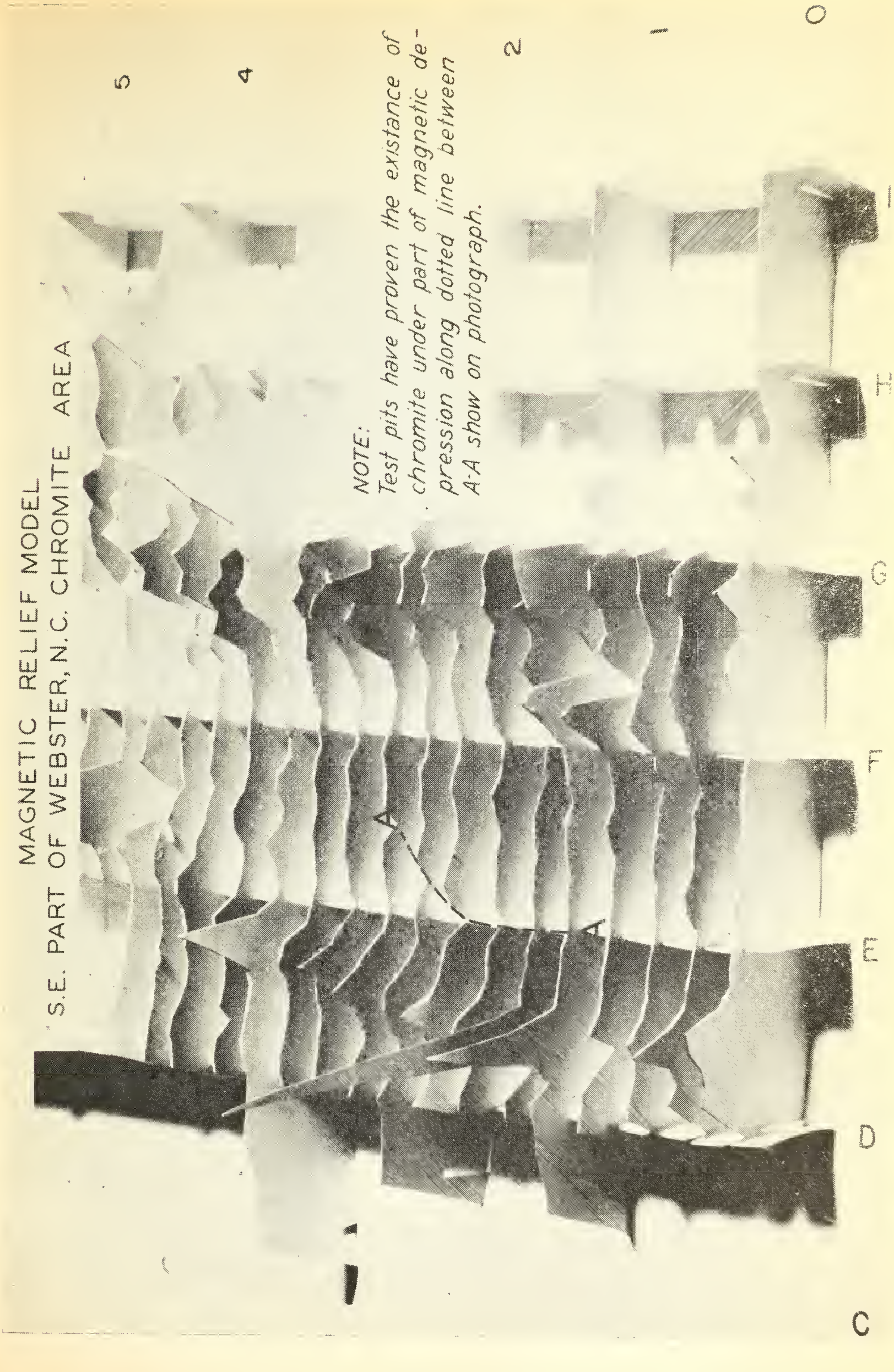

MAGNETIC RELIEF MODEL
N.W. PART OF WEBSTER. N.C. CHROMITE AREA
NOTE:
Chromite is known to exist under part of the area between A and A shown on the photograph. The flat area between B and B is underlain by uniform mica schist.
A
A
B
B
C
7
8
9
10
11
12
13

PLATE 15


MAGNETIC RELIEF MODEL
S.E. PART OF WEBSTER, N.C. CHROMITE AREA
NOTE:
Test pits have proven the existance of chromite under part of magnetic depression along dotted line between A-A show on photograph.
5
4
2
1
0
A
A
C
D
E
F
G
H
I

parallel to, and 75 feet west of, line 12, etc. The east-west lines of the main grid were given consecutive letters of the alphabet, starting with "D" on the south, and ending with "I" on the north.[1] The expression C-50 indicates an east-west line 50 feet north of line C, G-96 one 96 feet north of line G, etc. Thus the small but very intense high already mentioned as lying near the southeast corner of the grid has its center near the point whose coordinates are D-40: 1.25.

INTERPRETATION OF RESULTS

As has already been mentioned, the most striking features of the magnetic picture are not the chromite ore bodies, but the sharply defined borders of the dunite intrusion, a talc-quartz vein which roughly follows line "H" along the northern border of the eastern half of the area, and the so-called border highs. These latter do not seem to be in any way associated with the presence of chromite, but of magnetite and ilmenite which appear to be strongly concentrated in these areas.

A rather sharply defined magnetic trough which starts near G-50: 7.00 and extends southeasterly through F-90: 6.25 seems to indicate some form of geologic structure—perhaps a fault—whose presence cannot be otherwise detected, since the available exposures are insufficient. While certain of the magnetic lows, such as the one centering at G-80: 9.20 might perhaps indicate the presence of chromite, it appears more likely that they are simply a result of slight variations in the country rock itself.

An interesting feature is the long magnetic trough which extends eastward from about G-80: 10.25 to G-80: 9.50, where it swings southeastward to G-65: 9.10, from which it continues nearly due east to about G-60: 9.75. This trough appeared to indicate a possible extension of the ore found in the series of pits and shafts near the northern boundary of the area. However, five drill holes in this general area (see section of this report on "Core Drilling Chromite Prospect, Webster, N. C.) failed to find more than about 10 per cent chromite except at holes "D" and "F" where pockets of 60 per cent and 25 per cent chromite respectively were encountered. From the drill logs, 3 per cent chromite would seem to be about the average figure. As has already been said, the magnetic method allows of no very exact depth determinations; therefore, the drill holes were all started outside of the magnetic indications, and run in at an angle so as to intersect the vertical plane passed through the axis of the magnetic trough at some depth. In this way it was hoped that the maximum amount of information might be obtained. While the results of the drilling are far from encouraging, it is still entirely possible that pockets of chromite may be present along the axis of the magnetic trough either above or below the point of intersection with the drill holes. One or two vertical holes, drilled over the intersection of hole "D" or "F" with the vertical plane passed through the axis of the magnetic trough at about G-75: 11.00 and G-60: 8.75, might give additional information on this point. Hole "E" intersected the narrow disseminated chromite zone occurring under the cut to the northeast. The circular "low" centering near G-25: 7.90 a short distance south of hole "E" was not drilled because of the difficulty encountered in drilling hole "E".

In the southeast part of the area the magnetic low which may be associated with the chromite exposed in the cut at about E-00: 1.50 to E-00: 1.80 swings somewhat toward the

1. Lines A, B, and C were laid out, but were not used.

northwest and crosses the 2.00 line at about E-20, whereas the excavation turns the other way, suggesting that the chromite body splits somewhere near the western end of the working. It might be worth while to extend the cut along the axis of the low northwest from E-00: 1.80 to about E-00: 2.00. The series of small, more or less continuous lows along the "E" line just north of the southern border highs in the southeastern part of the area from 1.75 to 2.75 (perhaps to 3.75) seems also to be worth investigating, as might also the low located at approximately E-50: 4.00, where some massive chromite float was found.

None of the large, subcircular lows, such as those mapped in the northwest part of this area, appear as favorable as those just mentioned. The two drill holes ("C" and "E") near these circular "lows" showed greater than average depth to bedrock, and it may well be that the extra depth of weathered material present at these points is responsible for the lows.[1] Were it not for the fact that it appears to lie outside of the dunite area, the long, continuous, small low running approximately along the H-25 line from 7.50 to 10.50 would appear to be well worth investigating. The only other favorable indication in this area is the small low at about G-25: 12.25. All these localities are located on the geologic map (see Plate 9).

RECOMMENDATIONS

In view of the results obtained by the six holes already drilled, no strong recommendations for further exploratory work can be made. However, it should be pointed out that none of the pits and shafts so far dug are deep enough to give a very clear picture of the form and size of the ore bodies. If they are in the form of definite sheet veins, the angle holes already drilled should have intersected them at depth. If, on the contrary, they are in the form of more or less separate lenticular masses, the angle holes may very well have missed any ore body present by passing either above or below it. Before the prospect is definitely abandoned, several more drill holes should be sunk along the magnetic indications, this time as vertical, rather than as angle, holes. In view of the fact that in the magnetic latitude of North Carolina magnetic indications are offset southward by an amount which is approximately 10 per cent of the depth to the objects which produce them, it might be well to locate all vertical drill holes 8 to 10 feet north of the centers of the indications which are being tested. Or, what amounts to the same thing, instead of being exactly vertical, the drill holes might be started in the centers of the indications, and slanted northward at an angle of about 85 degrees to the horizontal. It is further recommended, that if any drilling is done at either of the Democrat areas or additional drilling at Webster, both vertical and angle holes be tried.

DEMOCRAT AREA

At Democrat there are two more or less distinct chromite-bearing areas, separated by a large mass of pegmatite. The more northerly portion of this chromite deposit is here referred to as the "North Democrat Area" and the more southerly part as the "South Democrat Area".

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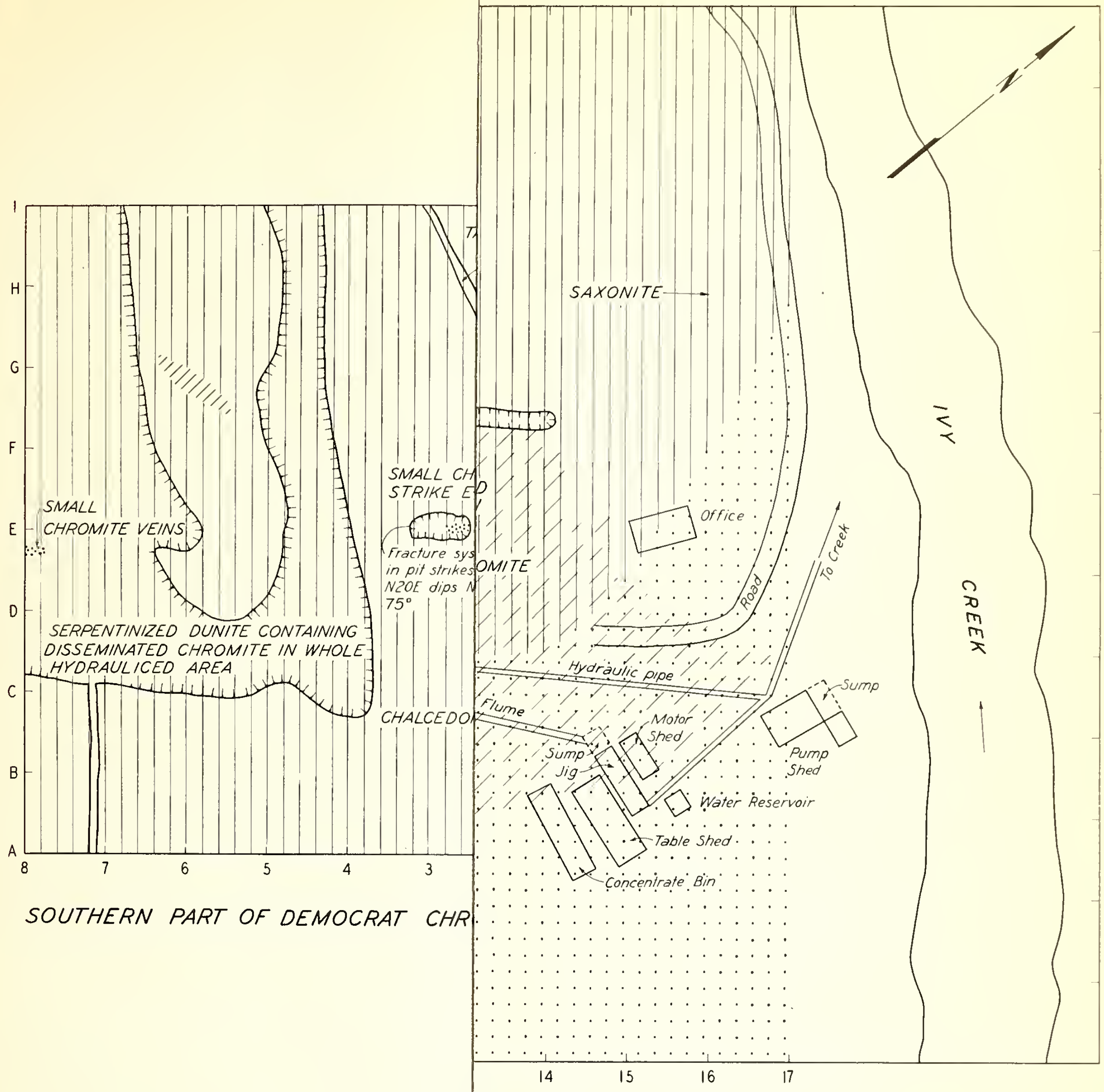
1. This suggestion was made by T. G. Murdock, of the N. C. Department of Conservation and Development.



SOUTHERN PART OF DEMOCRAT CHR DEPOSIT

Scale 25 0 25 50 Feet

CHROMITE SURVEY – DEMOCRAT, N C

GEOLOGICAL AND GEOPHYSICAL INVESTIGATION

TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT
AND
N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES

F.C.A.

KNOXVILLE | 10-21-41 | W | CO | 1 | 821 K 2 R0 northwest and crosses the 2.00 line at about E-20, whereas the excavation turns the other way, suggesting that the chromite body splits somewhere near the western end of the working. It might be worth while to extend the cut along the axis of the low northwest from E-00: 1.80 to about E-00: 2.00. The series of small, more or less continuous lows along the "E" line just north of the southern border highs in the southeastern part of the area from 1.75 to 2.75 (perhaps to 3.75) seems also to be worth investigating, as might also the low located at approximately E-50: 4.00, where some massive chromite float was found.

None of the large, subcircular lows, such as those mapped in the northwest part of this area, appear as favorable as those just mentioned. The two drill holes ("C" and "E") near these circular "lows" showed greater than average depth to bedrock, and it may well be that the extra depth of weathered material present at these points is responsible for the lows.[1] Were it not for the fact that it appears to lie outside of the dunite area, the long, continuous, small low running approximately along the H-25 line from 7.50 to 10.50 would appear to be well worth investigating. The only other favorable indication in this area is the small low at about G-25: 12.25. All these localities are located on the geologic map (see Plate 9).

RECOMMENDATIONS

In view of the results obtained by the six holes already drilled, no strong recommendations for further exploratory work can be made. However, it should be pointed out that none of the pits and shafts so far dug are deep enough to give a very clear picture of the form and size of the ore bodies. If they are in the form of definite sheet veins, the angle holes already drilled should have intersected them at depth. If, on the contrary, they are in the form of more or less separate lenticular masses, the angle holes may very well have missed any ore body present by passing either above or below it. Before the prospect is definitely abandoned, several more drill holes should be sunk along the magnetic indications, this time as vertical, rather than as angle, holes. In view of the fact that in the magnetic latitude of North Carolina magnetic indications are offset southward by an amount which is approximately 10 per cent of the depth to the objects which produce them, it might be well to locate all vertical drill holes 8 to 10 feet north of the centers of the indications which are being tested. Or, what amounts to the same thing, instead of being exactly vertical, the drill holes might be started in the centers of the indications, and slanted northward at an angle of about 85 degrees to the horizontal. It is further recommended, that if any drilling is done at either of the Democrat areas or additional drilling at Webster, both vertical and angle holes be tried.

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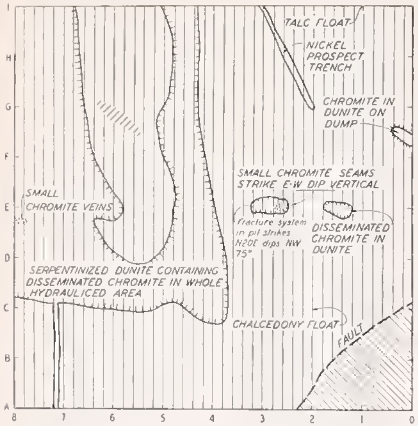
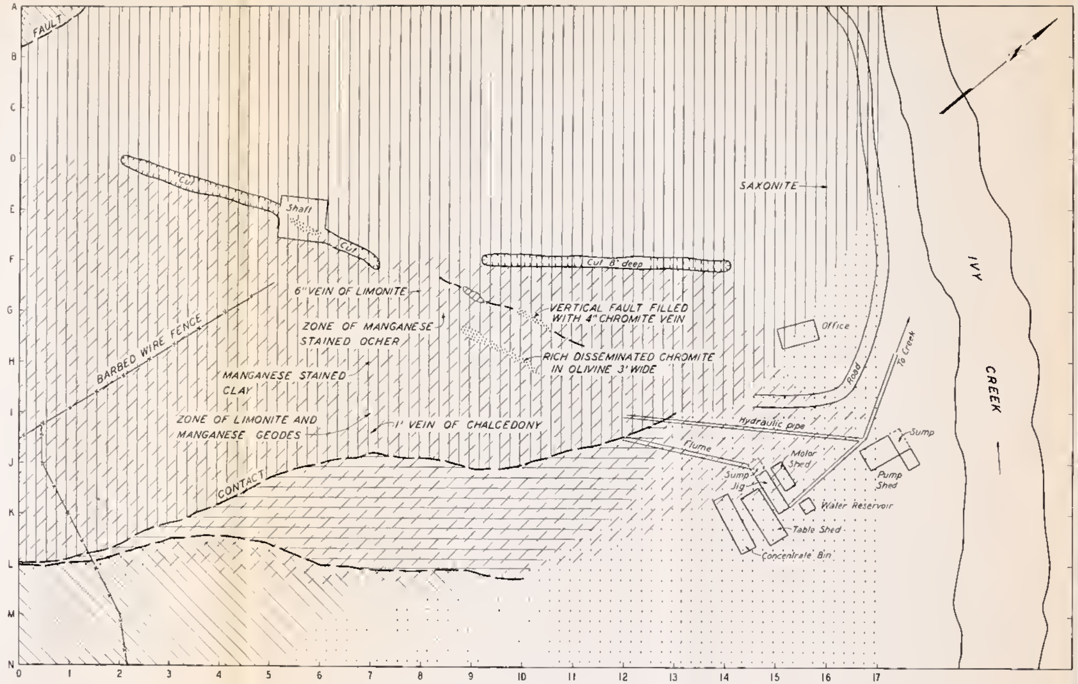
1. This suggestion was made by T. G. Murdock, of the N. C. Department of Conservation and Development.



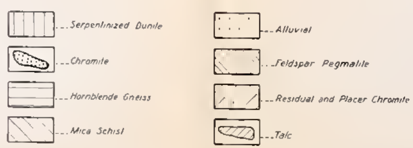
SOUTHERN PART OF DEMOCRAT CHROMITE DEPOSIT



NORTHERN PART OF DEMOCRAT CHROMITE DEPOSIT

Scale 25 0 25 50 Feet

SYMBOLS



CHROMITE SURVEY - DEMOCRAT, N C

GEOLOGICAL
AND
GEOPHYSICAL INVESTIGATION

TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT
AND
N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES

KNOXVILLE	10-21-41	W	CO	1	821K2

FCA

NORTH DEMOCRAT AREA

For this area a grid composed of lines spaced 25 feet apart was laid out. The southwest-northeast series was lettered from A to N, starting at the northwest boundary of the areas; the northwest-southeast series was numbered from 0 to 17, starting at the southwest boundary of the area. Magnetic traverses were run along the numbered lines, with observations taken every 10 feet except where wire fences, pipelines, etc., interfered.

Several old prospect pits and trenches, together with the hydraulic operations which were going on at the time of the survey, gave excellent exposures over much of the area. An iron pipe which carried water to the hydraulic monitor, and several barbed wire fences constituted enough magnetic interference so that certain portions of the region could not be covered completely by the survey. Aside from these areas of interference, traverses were run along the "north-south" lines with observations every ten feet, so that the magnetometer readings were taken at the intersections of a 10-by-25-foot grid.

Only two regions of marked magnetic contrast were found in this area. Near the east corner of the area a region of intense magnetism was encountered, with maximum anomalies of plus 17,790 and minus 20,566 gammas, a total range of 48,355 gammas. While no large masses of magnetite were seen, such anomalies could be due only to the presence of this mineral, while the positive and negative poles shown on the isogamic map (see Plate 17) indicate that the magnetite is not only magnetic, but is actually *polarized,* that is, exists as a natural magnet, or lodestone. A second pair of magnetic poles, but of much less intensity, was found along the "B" line between 3.00 4.10. Here the total anomaly was only about 3500 gammas.

No distinct border highs, like those found at Webster, were found.

INTERPRETATIONS AND RECOMMENDATIONS

In general, the magnetic indications in this area are less favorable than at Webster. The most promising indications are found along the lines of existing trenches and pits, say from about E: 3.00 to F-10: 7.00 to F: 10.00 to E: 12.00. However, these indications may be in part due to the removal of residual soil during earlier mining operations, and only in part to the presence of chromite. Although the relative importance of these factors cannot be assumed with any degree of assurance, it would seem that there may be some chance of finding chromite in place along this line. A vertical drill hole inside the area enclosed by the 800 gamma line which centers at about E: 4.00 might possibly show chromite, and the low extending almost due south from about F: 7.00 might also bear investigation. The low at E: 12.00 appears to be too "deep" to be of much value, although a prospect pit at this point might show something. The small highs on the "H" line at about 12:00 and 13:00 may perhaps be associated with the "vertical fault filled with 4″ chromite vein" shown on the geologic map as lying just west of them (see Plate 16), although the highs are probably not due to chromite.

Aside from closer examination of the points mentioned above, no recommendations for further trenching or drilling can be given on the basis of the magnetic data, and it would appear that this area must remain primarily a placer prospect.

SOUTH DEMOCRAT AREA

MAGNETIC SURVEY

A primary grid, spaced at 25-foot intervals, was laid out, with the lines parallel to those of the North Democrat area. The northeast-southwest lines were lettered from "A" to "I", starting with the southeastern border of the area, and the northwest-southeast lines were numbered from "0" to "8" starting with the northeast border of the area. Magnetometer readings were taken at 10-foot intervals along lines parallel to those of this primary grid, but spaced 10 feet apart, so that a complete set of readings located at the corners of 10-foot squares was obtained. Plate 19 is an isogamic map and Plate 20 is a photograph of the cardboard model constructed for this region.

INTERPRETATIONS AND RECOMMENDATIONS

Although no particularly favorable indications were obtained in this area, these localities might be worth further investigation: (1) the small low just northeast of the "1.00" line, and centering around "D", with perhaps an extension toward E: 0.10. This may be connected with the "disseminated chromite in dunite" shown just west of it on the geologic map. (2) The small low just south of the high near G: 2.20 in the northwest corner of the model, and running approximately from F: 2.10 to G: 2.30. However, this low may be associated with the "nickel prospect trench" shown on the geologic map, rather than with chromite. (3) The small low centering near E: 2.20 and extending about 20 feet to the east of that point may be connected with the "small chromite seams" shown near E: 2.15 on the geologic map. (4) The low extending from D: 4.30 to G: 6.20 also appears to be of some interest, but since it lies within the area where hydraulic operations have been carried out, it may be the result of these activities rather than being caused by the presence of chromite.

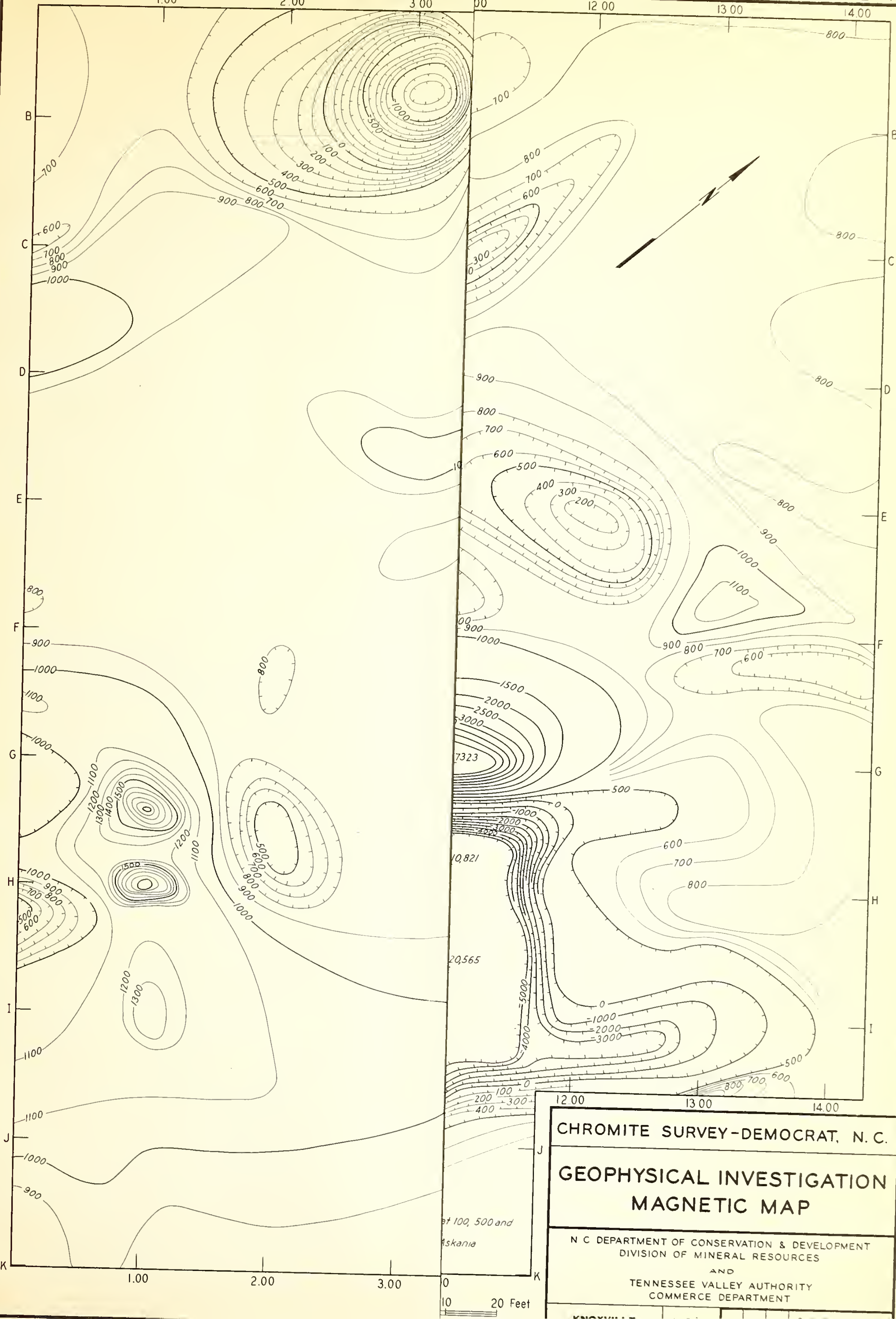
GENERAL CONCLUSIONS

In neither the Webster nor the Democrat areas were any extremely good indications of chromite ore bodies obtained. In the Democrat areas little, if any, further exploratory work can be recommended, although the areas mentioned above might bear further investigation. In the Webster area slightly more favorable indications were obtained, and two or three more drill holes, located as recommended, seem to be called for.

CORE DRILLING OF WEBSTER CHROMITE PROSPECT

Results of the geological investigations of the chromite deposits in western North Carolina indicated that the areas near Webster and Democrat were the most likely to be of commercial value. These areas were studied in detail, and magnetic geophysical surveys were made on selected parts of each area. Results of such surveys indicated the location of probable chromite deposits. With these data as a basis, the northwestern section of the Webster area appeared to have the greatest concentration of chromite, and therefore was selected for core drilling.

The purpose of the core drilling was to determine whether the magnetic anomalies found in the geophysical survey indicated the existence of underlying chromite bodies. In addition, it was hoped that the core drilling would aid in determining the extent of the con-



CHROMITE SURVEY-DEMOCRAT, N. C.
GEOPHYSICAL INVESTIGATION
MAGNETIC MAP
N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT
1.00
2.00
3.00
12.00
13.00
14.00
B
C
D
E
F
G
H
I
J
K
N
t 100, 500 and
Askania
0
10
20 Feet

SOUTH DEMOCRAT AREA

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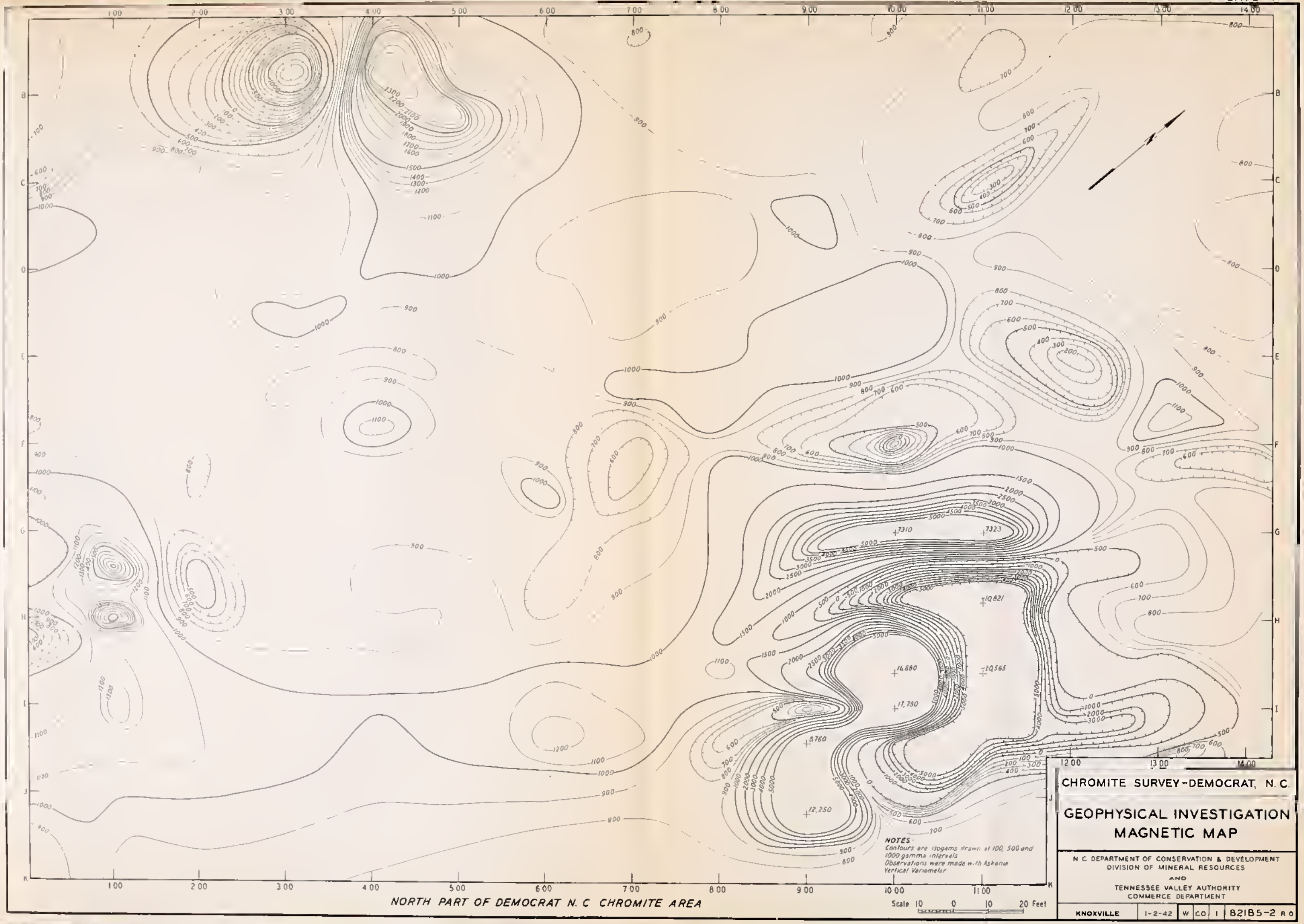
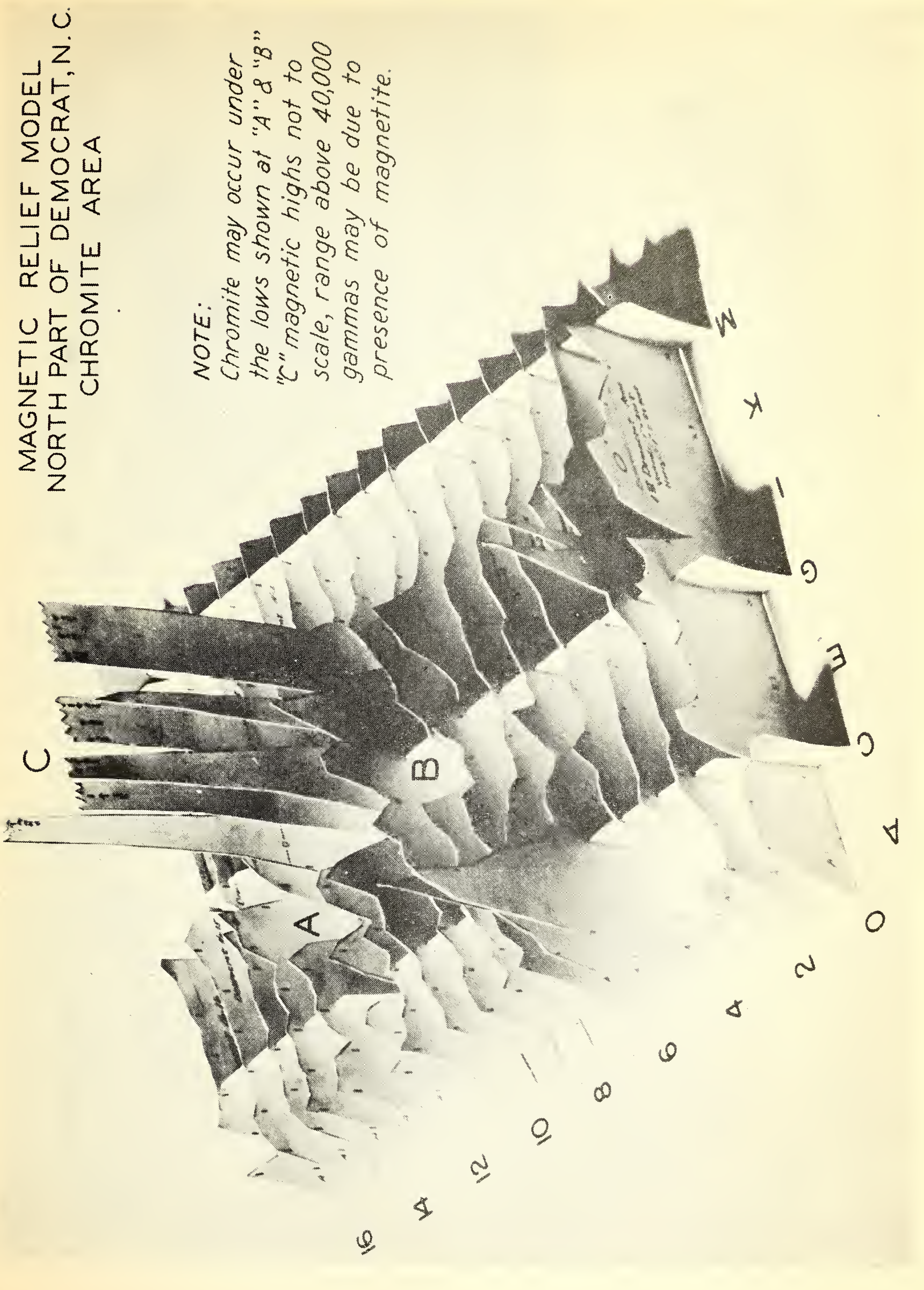
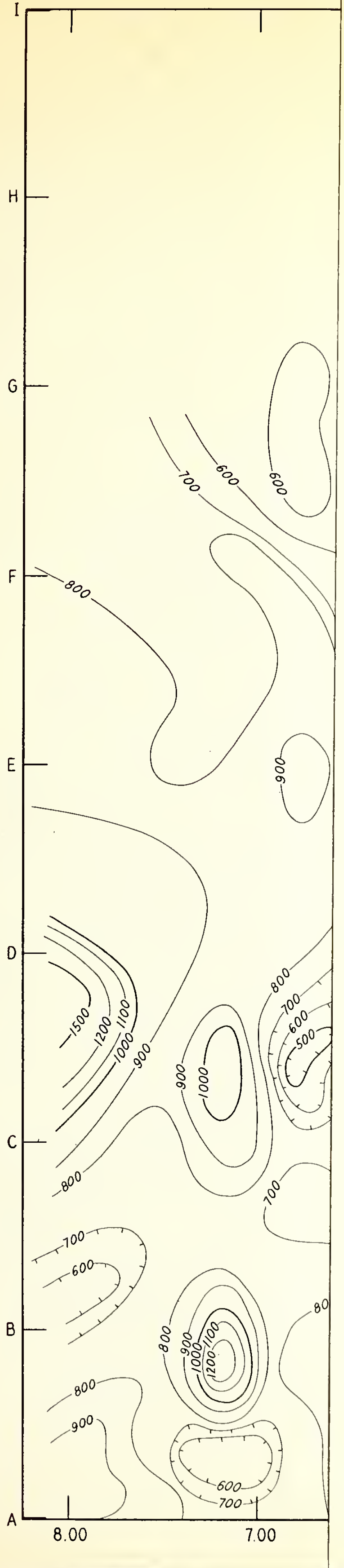
PLATE 17


CHROMITE SURVEY-DEMOCRAT, N. C.
GEOPHYSICAL INVESTIGATION
MAGNETIC MAP
N. C. DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT
KNOXVILLE
1-2-42
82185-2
NOTES
Contours are isogams drawn at 100, 500 and 1000 gamma intervals
Observations were made with Askania Vertical Variometer
Scale 10 0 10 20 Feet
NORTH PART OF DEMOCRAT N. C. CHROMITE AREA


MAGNETIC RELIEF MODEL
NORTH PART OF DEMOCRAT, N. C.
CHROMITE AREA
NOTE:
Chromite may occur under the lows shown at "A" & "B"
"C" magnetic highs not to scale, range above 40,000 gammas may be due to presence of magnetite.
A
B
C
M
K
I
G
E
C
A
0
2
4
6
8
10
12
14
16



NOTES:
Contours are isogams drawn at 100 and 500 gamma intervals
Observations were made with Askania Vertical Variometer.

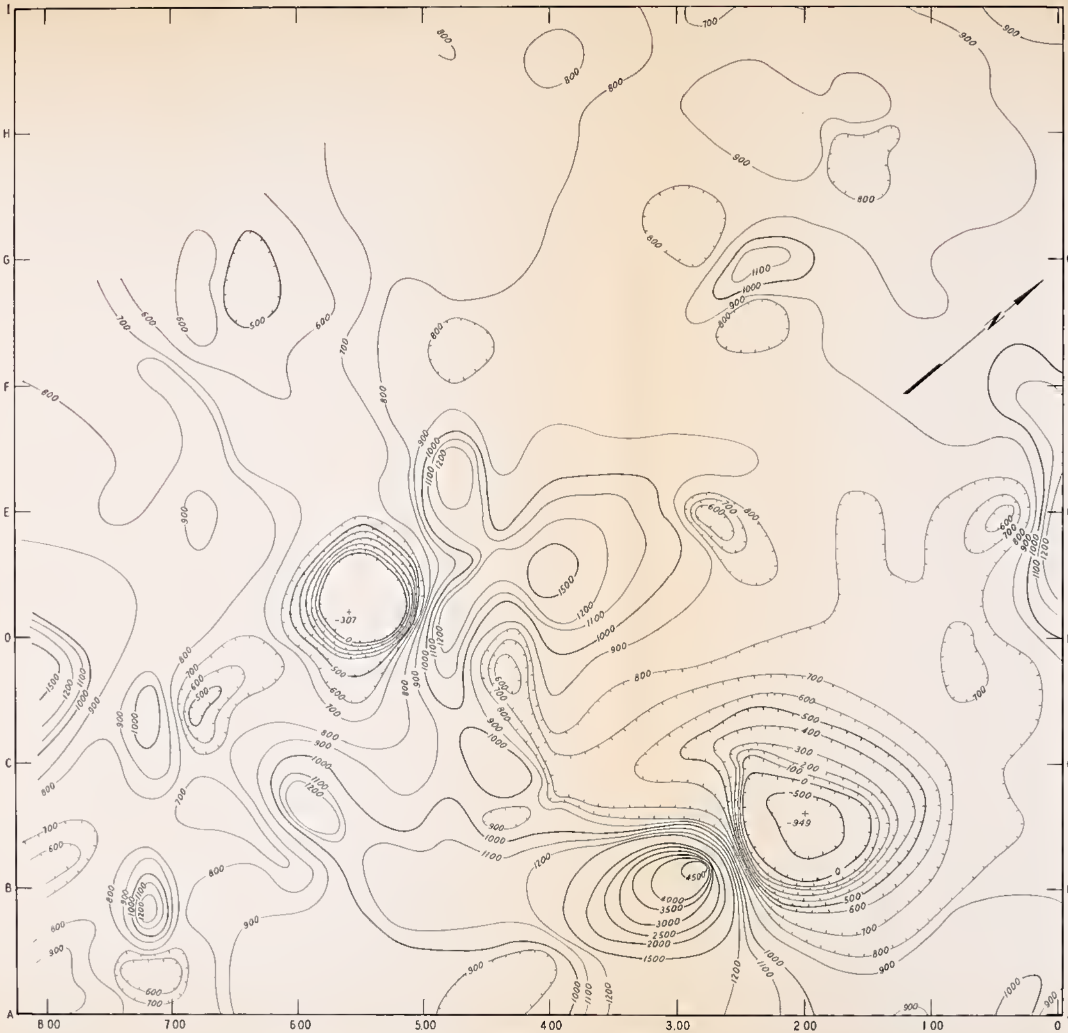
Scale 10 0 10 20 Feet

CHROMITE SURVEY – DEMOCRAT, N. C.

GEOPHYSICAL INVESTIGATION
MAGNETIC MAP

N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

KNOXVILLE	1-2-42	W	CO	1	821B5-1 RO



SOUTH PART OF DEMOCRAT N.C CHROMITE AREA

NOTES.
Contours are isogams drawn at 100 and 500 gamma intervals
Observations were made with Askania Vertical Variometer

Scale 10 0 10 20 Feet

CHROMITE SURVEY—DEMOCRAT, N. C.

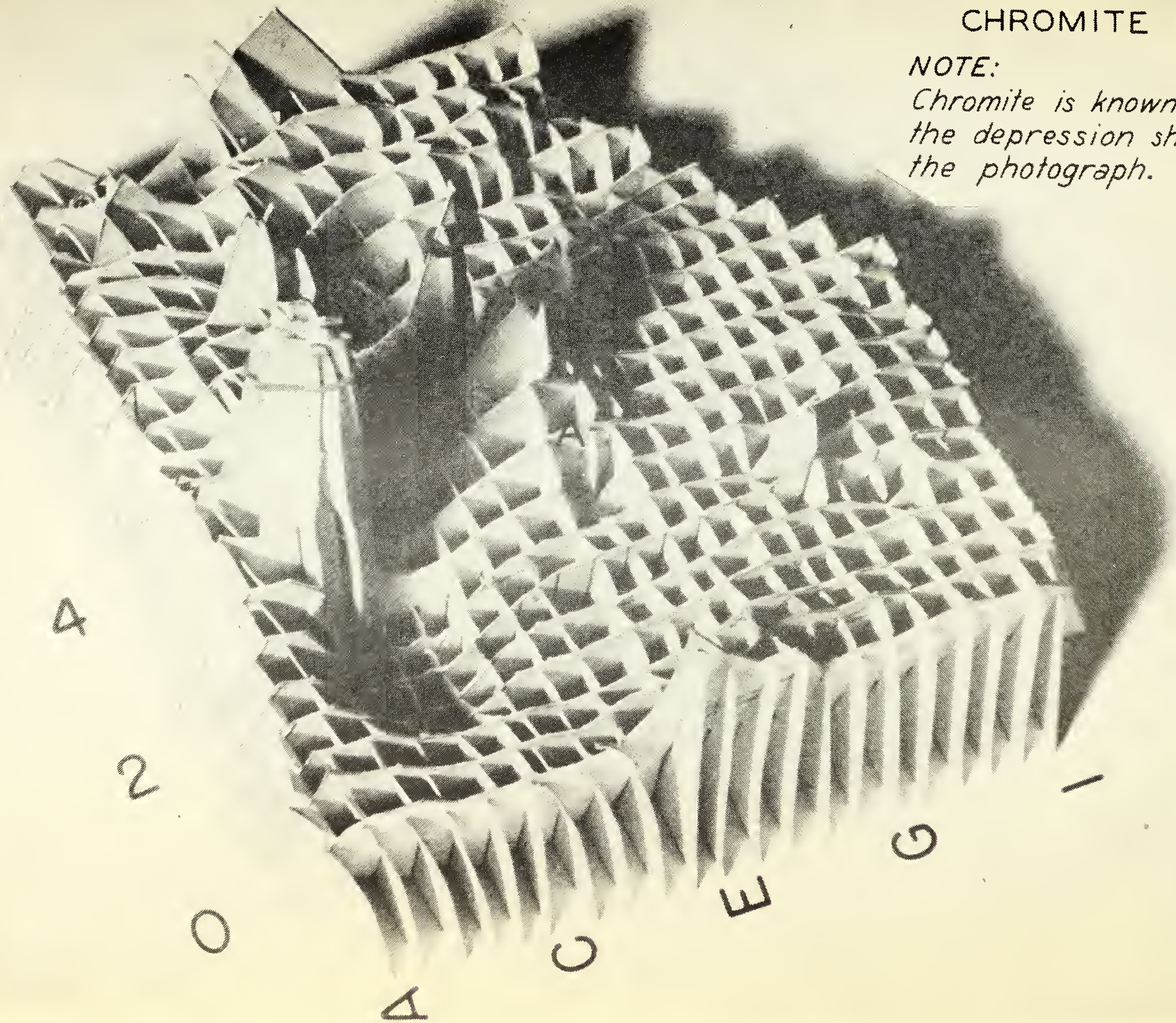
GEOPHYSICAL INVESTIGATION
MAGNETIC MAP

N C DEPARTMENT OF CONSERVATION & DEVELOPMENT
DIVISION OF MINERAL RESOURCES
AND
TENNESSEE VALLEY AUTHORITY
COMMERCE DEPARTMENT

KNOXVILLE	1-2-42	W	CO	I	82185-I R0

MAGNETIC RELIEF MODEL
SOUTH PART OF DEMOCRAT, N. C.
CHROMITE AREA

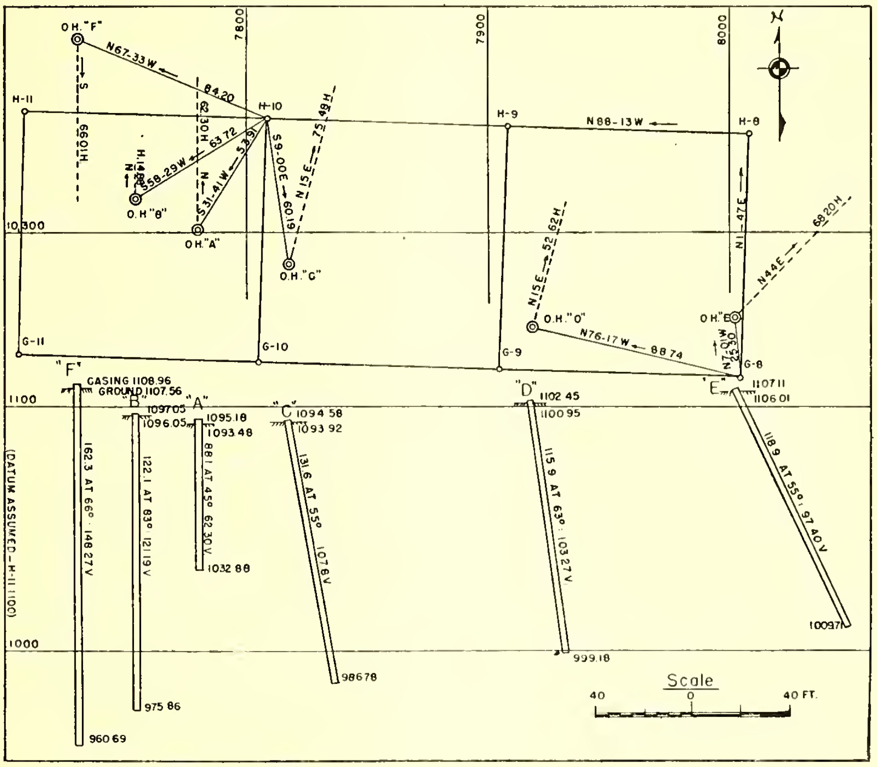
NOTE:
Chromite is known to occur under the depression shown at "A" on the photograph.



cealed ore bodies. At the time of this drilling, it was the intention of the Conservation Department and the Authority to drill other selected areas if the drilling at Webster proved successful.

The locations of these core drill holes were so selected as to intersect points of likely occurrences of chromite as indicated by magnetic results or geological features. Six angle holes, totaling 738.8 feet, were drilled. (For location of holes see Plate No. 21). Reports[1] showing the coordinate layout used in the geophysical survey and the location of the core drill holes are on permanent file with the Commerce Department of the Tennessee Valley Authority at Knoxville, Tennessee, and the Division of Mineral Resources, North Carolina Department of Conservation and Development, Raleigh, North Carolina.

PLATE 21



The drilling was done with a Sullivan drill, type 12, taking a core $2\frac{1}{8}$ inches in diameter. In Holes B, E, and F the core was reduced to $1\frac{1}{8}$ inches near the bottom because of unfavorable ground conditions. The core recovery was quite good considering the extremely broken conditions of the dunite rock in which the drilling was done. The frequent occurrence of soft nickel silicate minerals, veins of chalcedony, and silica residue

1. Murdock, T. G., "Horizontal Control—Webster and Democrat, N. C. Chromite Investigation," R. I. 24 and 25, Division of Mineral Resources, North Carolina Department of Conservation and Development, Raleigh, N. C. "Location of Diamond Drill Holes, Webster, N. C. Chromite Investigation."

made part of the drilling rather difficult. Since the chromite was found to occur in fracture zones, often filled with talc or weathered soft dunite, the core loss was rather high at the points where the chromite occurred.

The results of the drilling were not very encouraging as the coring did not penetrate any outstanding chromite ore bodies. All the holes encountered one or more chromite zones but none of sufficient size to be of commercial importance under normal conditions. Holes B, D, and F, intersected narrow zones of vein chromite up to 2½ feet thick. Hole D apparently intersected at a depth of 97 feet the same chromite vein-zone exposed in the overlying cut. In the cut the chromite zone is from 1 to 3½ feet thick. Assuming that this chromite vein-zone extends along the strike for 25 feet each way from the bottom of the cut or the drill hole and that the chromite is continuous from the cut to its point of intersection by the hole 90 feet below the cut, there is more than 600 tons of chromite at Hole D. Of the 738 feet drilled, about 165 feet contains approximately 2½ per cent disseminated chromite.

All six holes intersected numerous nickel silicate mineral seams (genthite and garnierite)[1] composed of soft material difficult or impossible to core. Much of the core loss was due to these nickel silicate zones. Hole B intersected soft nickel silicate at a depth of 117 feet, which indicates the depth to which these secondary nickel minerals have been formed. In the upper 75-foot zone of all the holes nickeliferous seams occur every few feet which are identical with those exposed at the Olivine Products Company plant at Webster. The average of the analyses[2] of these nickel seams at Webster is 5.34 per cent NiO. The drilling disclosed the existence of more nickel silicate mineral seams than were previously thought to exist in the area drilled. The possibilities of producing nickel along with chromite in the Webster area should not be overlooked.

The drilling proved that the magnetic "trough lows" are mainly due to sound granular olivine containing less than 5 per cent disseminated chromite. The broad circular magnetic "lows" were found to be due to clay pockets formed by deep weathering. The drill holes did not encounter as much chromite as is exposed in the surface cuts and pits. The drilling proved that the chromite bodies are mainly small disconnected lenses.

Core drilling does not adequately explore chromite lenses of the type occurring in western North Carolina as these lenses are so small and discontinuous that there is much barren ground between them. Therefore, drill holes may miss the chromite lenses entirely as the barren area is likely to be greater than the area represented by the small chromite body.

The following logs give a more detailed account of the core drilling.

1. Eckel, E. C., and others, "Iron, Chromite and Nickel Resources of the Tennessee Valley Region," TVA Geologic Bulletin No. 10, p. 22, 1938.
2. Pawel, G. W., "Nickel in North Carolina," *Engineering and Mining Journal*, October 1939, p. 35.

GENERALIZED LOGS[1] OF CORE DRILL HOLES, WEBSTER, JACKSON COUNTY, NORTH CAROLINA

HOLE NUMBER A

Location: H-10, S. 31° 41″ W., 53.91 Feet; Surface Elevation 1093.48[2] Angle 45°; Direction, North.

Depth in Feet From	To	
0	13.8	Clay (red).
13.8	23.9	Weathered dunite containing about 2% disseminated chromite. Core loss about 25%.
23.9	27.8	Relatively sound dunite, chalcedony and talc seams. Core loss 25%.
27.8	34.5	Weathered dunite, talc veins containing chromite blebs and numerous small nickel silicate veins (genthite and garnierite). Core loss 10%.
34.5	44.7	Relatively sound dunite containing small seams of nickel silicate minerals. Core loss 10%.
44.7	55.7	Very sound coarse-grained dunite containing about 2% disseminated chromite.
55.7	61.5	Sound dunite containing small nickel silicate seams.
61.5	71.7	Weathered and sound dunite containing talc and nickel silicate seams.
71.7	74.5	Chalcedony and silica residue from leached olivine. Core loss 70%, probably mostly soft green nickel silicate minerals.
74.5	76.2	Relatively sound dunite containing about 2% disseminated chromite.
76.2	78.2	Broken fault zone filled with talc and white tough asbestos. Core loss 25%.
78.2	78.7	Very sound dunite.
78.7	80.0	Fault zone filled with talc, actinolite, chlorite, and vermiculite.
80.0	88.1	Relatively sound dunite containing talc and chalcedony seams.
	88.1	Bottom of hole. Hole filled at 40 feet by cave-in.

HOLE NUMBER B

Location: H-10, S. 58° 29″ W., 63.42 Feet; Surface Elevation 1096.05 Angle 83°; Direction, North.

Depth in Feet From	To	
0	5.1	Red clay and weathered rock.
5.1	11.3	Weathered dunite containing about 3% disseminated chromite.
11.3	26.7	Highly weathered dunite and soft nickel silicate seams. Chromite in cuttings. Core loss 90%.
26.7	31.3	Weathered dunite containing about 2% disseminated chromite.
31.3	51.2	Alternating weathered and sound dunite containing talc and nickel silicate veins. Estimated to contain about 3% chromite.
51.2	54.0	Partly weathered dunite containing about 4% chromite.
54.0	55.5	Weathered dunite and chalcedony. Core loss 95%.
55.5	60.0	Weathered and sound dunite containing a little disseminated chromite and nickel silicate veins.
60.0	66.0	Highly jointed and weathered dunite containing talc and nickel silicate veins. Fault at 63 in which there are ½ inch chromite crystals.
66.0	84.8	Sound and weathered dunite containing 2% disseminated chromite.

1. Detailed logs are on file with the Division of Mineral Resources, North Carolina Department of Conservation and Development, Raleigh, N. C., and the Regional Products Research Division of the Commerce Department of the Tennessee Valley Authority, Knoxville, Tennessee.
2. Datum for elevations is not sea-level but arbitrarily taken as 1,100 feet for Station H-11 on the grid.

HOLE NUMBER F

Location: H-10, N. 67° 33″ W., 84.20 Feet; Surface Elevation 1107.56 Angle 66°; Direction, South.

Depth in Feet *From*	*To*	
0	13.1	Weathered mica schist.
13.1	14.3	Asbestos and talc.
14.3	25.5	Talc, vermiculite, and soapstone.
25.5	28.8	Laminated soapstone.
28.8	33.9	Chlorite schist and talc.
33.9	35.2	Chalcedony, talc, and silica residue from leached dunite.
35.2	82.7	Talc, soapstone, chalcedony, and nickel silicate seams, 60% core recovery.
82.7	94.0	Highly weathered serpentinized dunite, talc, and nickel silicate seams. Serpentinized dunite appears to contain about 3% disseminated chromite.
94.0	115.2	Highly fractured and steatitized dunite. Parts of zone contain about 3% disseminated chromite.
115.2	117.1	Talc zone impregnated with chromite crystals. Probably 25% chromite. 50% core loss.
117.1	123.1	Highly weathered and steatitized dunite. Contains small amount of chromite.
123.1	124.4	Highly laminated dunite.
124.4	126.5	Weathered and broken talc and dunite containing both vein and disseminated chromite. 60% core recovered. Chromite content estimated at about 15%. (Note that this is probably the same chromite zone as that showing in shaft over hole).
126.5	135.9	Serpentinized and sound dunite, containing about 2% disseminated chromite.
135.9	141.0	Broken dunite cemented with green talc, containing about 3% disseminated chromite.
141.0	143.1	Chromite and talc. 50% core loss.
143.1	144.3	Weathered dunite and talc.
144.3	144.9	Chromite and talc. Water lost at 144.9.
144.9	150.0	Weathered dunite. 20% core loss.
150.0	151.7	Talc and chromite.
151.7	157.2	Vermiculite, asbestos, talc, chlorite. 30% core loss.
157.2	162.7	Sound green dunite containing about 2% disseminated chromite.
	162.7	Bottom of hole.

MINING OF CHROMITE

The mining of chromite from the North Carolina deposits has in the past presented certain difficulties, due principally to its occurrence in discontinuous, irregularly shaped, roughly lenticular bodies varying widely in size as well as shape. As previously stated, it may also occur disseminated as grains, arranged in bands of varying grade, in the dunite masses, and as crystals and fragments in soil overburden.

PROBLEMS OF CHROMITE MINING

The problems of chromite mining in general have been outlined by Nixon,[1] and while this exposition was with reference to the Oregon deposits it is in many respects quite ap-

1. Nixon, E. K., "Chromite—An Immediate National Need." Oregon Department of Geology and Mineral Resources. *The Ore Bin.* Vol. 4, No. 1 (Jan. 1942), p. 3.

plicable to those in North Carolina. Briefly stated, once chromite is found in place, development work is required in order to indicate the extent and attitude of the occurrence. This work usually means, first, surface cuts and trenches and, second, underground work in the form of shaft sinking and drifting. The amount of development required, will, of course, depend upon the size of the deposit. In the case of a small ore body, development work usually will extract all of the ore, and thus development and mining go hand in hand. Mining of small ore deposits is done by hand, since the quantity of ore available may not warrant purchase of power drilling equipment. For large proved deposits, power equipment applicable for mining any lode deposit would be suitable. Speaking generally, however, power equipment should be kept at a minimum in advance of fairly accurate knowledge of the extent of the ore body. Small deposits usually require hand sorting as the ore is mined, in order that all waste be removed and only the best ore obtainable retained for shipment. In mining larger deposits, hand sorting for removal of waste, insofar as practical, should be done. Concentration by milling equipment may be practical provided the proved extent of the deposit warrants the necessary capital expenditure and provided the ore is of such character that sufficiently high-grade grains of chromite may be mechanically separated from the gangue. In the case of chromite sands, a concentrating plant is essential and requires specialized operation. Such operations should not be undertaken except by technically qualified operators. In all cases where milling plants are contemplated, they should be designed by a qualified metallurgist and planned only after proper testing work is completed. Some low-grade chromites are not amenable to treatment mechanically so as to produce a satisfactory concentrate.

Unit cost of mining (cost per ton) is an elastic figure, but is usually interpreted as including all costs incident to getting the ore to a surface stockpile or to the concentrator bins. Very little information on the cost of mining chromite in the United States is available, since up to 1941 there was practically no domestic production. Costs will vary widely depending upon the size, type, and location of the deposit, and upon the experience of operators. This is true for any mineral deposit, but is especially applicable to discontinuous, lens-like ore bodies in the mining of which the proportion of dead work to total quantity of ore removed is high. In the cost of mining lode chromite, as in other lode deposits, the labor cost would be by far the largest single item and might amount to 70 or 80 per cent of the total cost of extraction. Added to this would be the cost of explosives, sorting, power, timbering, supervision, assaying, and any dead work necessary in opening the deposit. Unit cost of mining small or medium-size deposits may be \$6.00 or \$7.00 and up per ton. The critical factors in lode chromite production are grade and size of deposit, together with transportation facilities. The critical factors governing operation of a chromite sand deposit are thickness of overburden, grade and extent of chromite sand. The importance of determininag the proper method of concentration has been mentioned above.

Placer Operations at Democrat

The only recently active chromite property in North Carolina is near Democrat just south of the Ivy River. Here the occurrence of chromite sand as crystals and fragments of chromite in the soil overburden capping, and derived from the weathering of the underlying dunite mass was of sufficient richness to permit its exploitation, even under existing economic conditions. Such an occurrence as a chromite sand offers no difficulties to modern placer mining methods; in fact, an adjacent area was worked to a limited extent during 1917-18.

For several months during the summer and fall of 1941, the Southern Minerals Company of Asheville carried on operations at the property, first treating an old concentrate pile remaining from previous work. The equipment in use involved the minimum expenditure possible and also had the advantage of being readily portable, thus permitting its transfer to another area in the same district, to some other chromite property, or even to some other region to undertake the exploitation of another mineral which might offer greater possibilities of profit under changing economic conditions.

Conditions are quite favorable for placer operation in that a sufficient amount of water is available in the Ivy River, the shape of the hill to the south is such that the sluiced material flows readily down to the feed sump, and the river permits ready disposal of the fine tailings. An unfavorable factor is the thinness of the chromite-bearing soil overburden as in many places sound bed rock of dunite is encountered within three feet of the surface. The thickness of the overburden increases to the south of the area being sluiced at the time of examination.

The equipment for mining and concentrating consisted of two pumps mounted on rubber-tired trailers, for pumping into tanks supplying the jig and table, and for washing the chromite-bearing overburden down into the sluice; a bucket elevator for feeding the jig with the sluiced material; a Pan-American two-compartment duplex jig of the balanced type; a James standard Wilfley table 4½ feet by 15 feet; and the necessary driving mechanism, pipe lines, tanks, hose, and sluice box. A trommel was later installed between the bucket elevator and jig to permit the removal of trommel screen oversize waste material without its having to pass the jig as was the original procedure. Plate 16 shows the location of the various plant units.

The operating procedure may be briefly described as follows. The chromite-bearing soil was washed by a nozzle, water pressure being 75-100 pounds, and water consumption at least 500 gallons per minute. The washed material was thus sluiced by gravity into a wooden flume and thence to a dewatering pit adjacent to the concentrating unit, passing over a grizzly where large boulders, weeds, and trash were removed. From this pit a bucket elevator discharged the feed into the Pan-American jig. The jig consisted of two cells, the first of which had a 1/16 inch screen and the second a 3/16 inch one, and was operated at 100 pulsations a minute. The coarser concentrate from the jig went to concentrate storage; the finer material to the table; and the jig tailings to the waste pile. The table made 250 to 300 vibrations per minute and produced three products: a concentrate to storage, a middling which was returned to the circuit, and a tailing to waste disposal. Water consumption of the jig and table amounted to 350 gallons per minute, under a constant head of 16 to 20 feet. Mechanical methods of transfer from jig to water were to be installed and also for disposal of coarser waste material. With these refinements it appeared possible to operate the plant with a four-man crew. The plant flow sheet is shown in Plate 22.

The plant units were driven by gasoline motors: a 5-hp motor for the elevator, a 3-hp one for the jig, and a 1½-hp one for the table.

Plant capacity was 100-150 tons of feed per eight-hour day, which could have been increased with some changes in the flow sheet. Chromite production amounted to 3 to 4 tons of concentrate per day; the product was around 48 to 50 per cent chromic oxide although a concentrate as high as 55 per cent could be obtained when desired. The following is a chemical analysis[1] of the chromite produced and of a hand-picked concentrate of pure chromite from the product:

	Cr_2O_3	*Cr*	*Fe*	*Si*	*P*	*S*
Table and Jig Concentrate	55.52	37.99	19.93	0.80	0.07	Trace
Hand-Picked	58.24	39.85	19.32	0.74	0.07	Trace

The occurrence of fine garnet in the overburden near the river indicated the possibility of its recovery as a by-product and some experiments were made upon such a procedure.

Mining at this property was discontinued early in 1942, despite the fact that the operations had been well planned and conducted with new and adequate equipment. The exact reasons for the cessation of operations are not known, but the apparent failure of the enterprise is a further indication of the difficulty of successfully working North Carolina chromite.

RECOVERY OF DISSEMINATED CHROMITE

The possibility of the recovery of the chromite occurring as disseminated grains or crystals in the olivine and weathered dunite, an occurrence which is fairly common throughout the entire olivine belt, is one which should receive due consideration. Such a process would offer little technical difficulty and it could probably be effected with equipment such as that used at Democrat by the addition of the necessary coarse and fine grinding units. Likewise the mining of the ore-bearing material would be a simple quarrying operation and would present no greater problems than does the production of olivine for refractory use with a certain amount of selective mining. However, a considerable tonnage of olivine would have to be processed to secure a ton of chromite, and the crushing and tailings disposal costs would be so high that the recovery would be of doubtful economy unless some market were found for the olivine.

The mining and preliminary crushing of olivine could probably be carried out for \$1.50, and allowing an additional \$1.00 for finer grinding and additional processing would mean a total of \$2.50 per ton of mill feed. If the value per ton of chromite concentrates is assumed to be \$40.50, the base price offered by Metals Reserve Company for "High Grade" chrome ores containing 45.0 per cent Cr_2O_3 and with a ratio of chrome (Cr) to iron (Fe) of 2.5 to 1, only 16.2 tons of feed could be milled at this price. This in turn would require a mill feed of 6.17 per cent chromite in the olivine, an average grade which appears difficult of achievement on a large scale. This example would also necessitate perfect mill recovery, even if the requirements of the market were met and production cost including overhead and amortization was not more than \$2.50. A greater chromite content would be necessary to provide any profit to the operator.

1. Chemical Analysis by J. W. H. Aldred, TVA Research and Development Division, Wilson Dam, Alabama.

The wider use and greater demand for olivine, however, will change the picture entirely. Any large scale development of the olivine deposits, particularly those known to be associated with the chromite occurrences described in preceding pages, such as to provide a raw material for the manufacture of magnesium salts or metal, may be expected to yield considerable by-product chromite at a low cost, both as pockets and lenses of massive chromite from mining and as disseminated chromite recovered from the residue and solution after the olivine has been processed for its magnesium content. In fact this is the future of the North Carolina chromite deposits.

PLATE 22

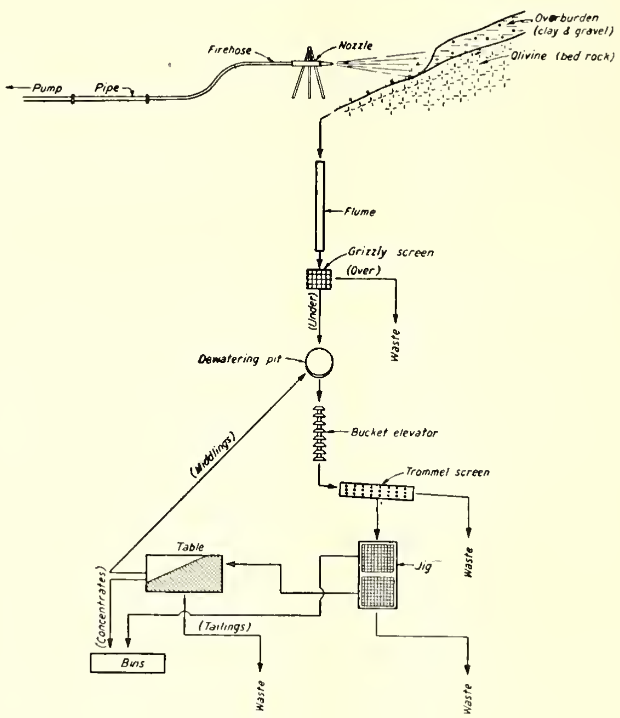


PLATE 23

FIGURE A. SMALL CHROMITE VEIN

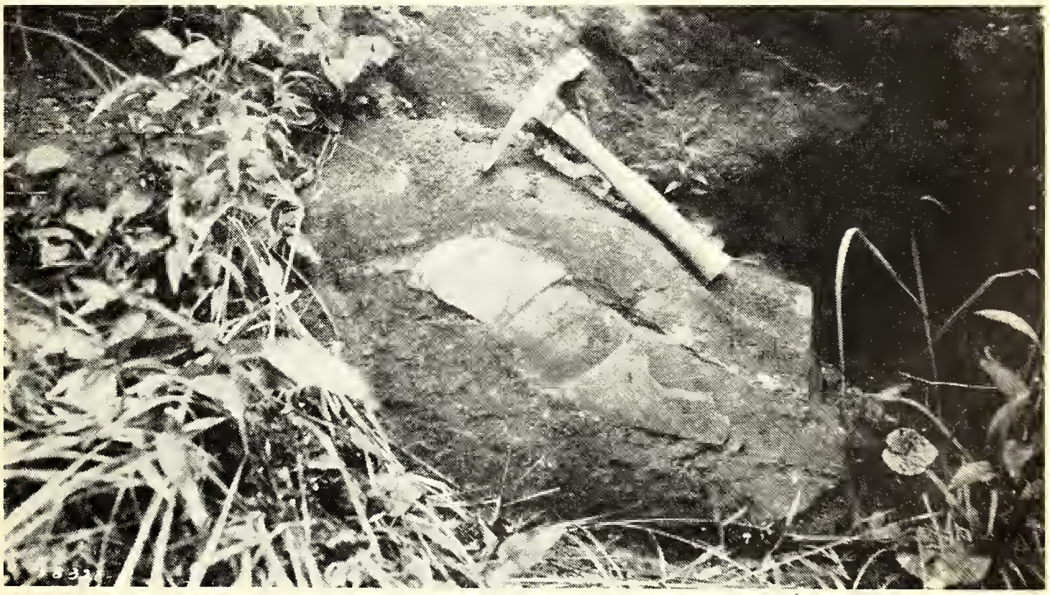


FIGURE B. SMALL CHROMITE LENS IN DUNITE

PLATE 24

FIGURE A. FIELD MAGNETOMETER PARTY IN ACTION

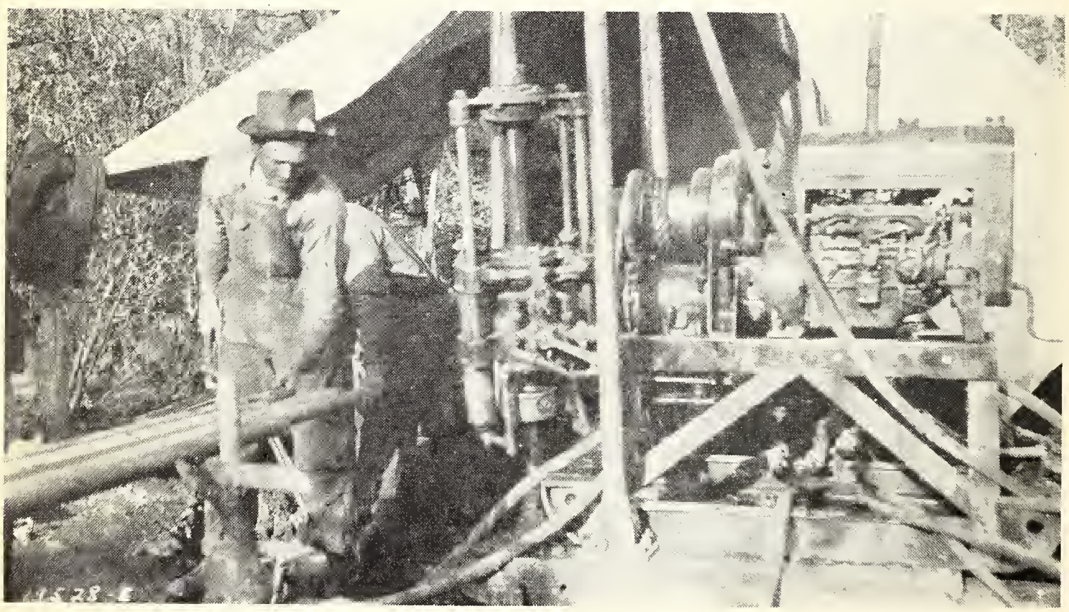


FIGURE B. CORE DRILLING FOR CHROMITE, WEBSTER, N. C.

PLATE 25

FIGURE A. HYDRAULICKING PLACER CHROMITE, DEMOCRAT, N. C.

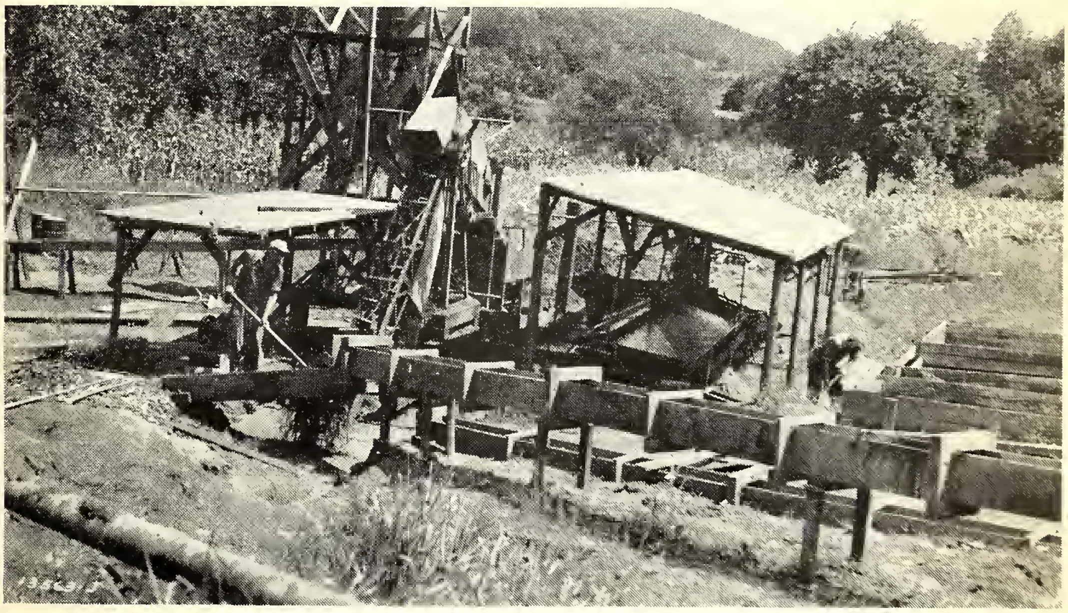


FIGURE B. PORTABLE PLANT RECOVERING PLACER CHROMITE, DEMOCRAT, N. C.